

SUMMARY

S. 1 INTRODUCTION

Sections S.1 through S.9 summarizes the Draft Environmental Impact Statement (DEIS) for the High Flux Beam Reactor (HFBR) Transition Project at the Brookhaven National Laboratory (BNL) in Upton, New York (DOE/EIS-0291D). The HFBR DEIS has been prepared by the U.S. Department of Energy (DOE) to analyze alternatives for the future of the HFBR. The HFBR has not operated since it was shut down for refueling and normal maintenance on December 21, 1996. Before the reactor returned to scheduled operations, it was discovered through the monitoring process that groundwater downgradient from the HFBR building had been contaminated with tritium, a radioactive isotope of hydrogen. The investigations that followed this discovery identified the HFBR spent fuel pool as the source of the tritium plume. The HFBR DEIS presents the measures taken to correct the contamination problem, and evaluates the potential environmental impacts of several options for the future of the HFBR. This document summarizes potential environmental implications of the decision on the future of the HFBR.

S. 2 PURPOSE AND NEED FOR DOE ACTION

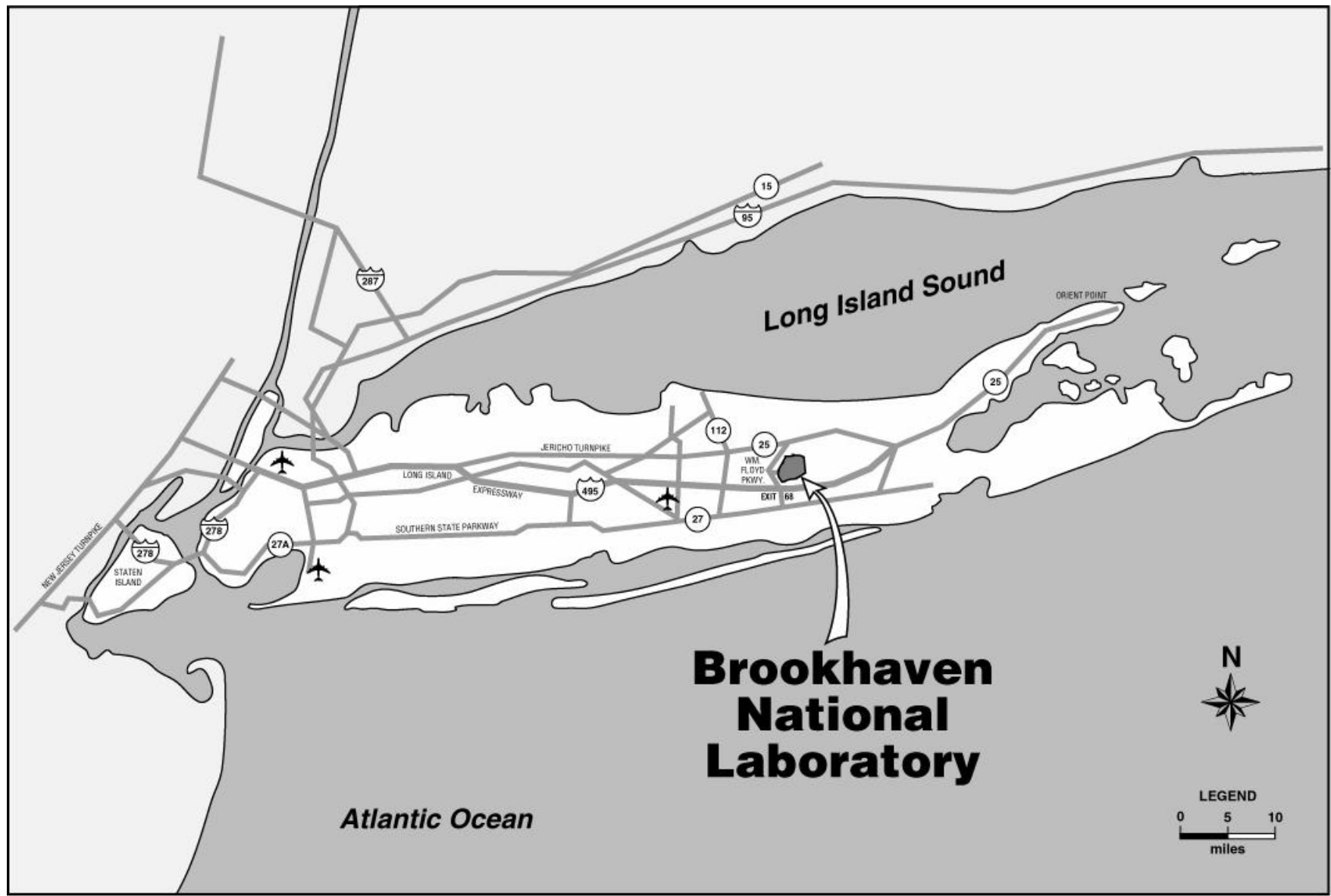
Public Law 95-91, dated August 4, 1977, assigned responsibility to DOE for assuring a coordinated and effective administration of Federal energy policy and programs. In turn, the Office of Science is charged with maintaining long-term scientific programs oriented to large-scale, high technology research and development. One aspect of this mission is the development and application of neutron-based research. Neutrons are a unique resource essential to research in the fields of physics, chemistry, medicine, and biological sciences, as well as for the development of new materials.

From its inception in 1965 until it was shut down in 1996, the HFBR had held the distinction of being one of the world's best sources of neutrons. Scientists from around the world came to BNL — situated near the geographic center of Suffolk County, Long Island, about 100 kilometers (km) (60 miles [mi]) from New York City (see Figure S.2-1) — to use neutrons at the HFBR in their investigations in solid state and nuclear physics, chemistry, medicine, and biology. As many as 280 scientists visited the HFBR each year to irradiate experimental samples in the reactor or to make use of the facility's intense neutron beams. The Federal government and the scientific community require a reliable source of neutrons to continue neutron scattering research. A source with capabilities similar to the HFBR does not currently exist in the United States.

DOE needs to make a decision on the future of the HFBR. That decision will be made from among four alternatives: No Action, Resume Operations, Resume Operations and Enhance Facility, and Permanent Shutdown. Each of these alternatives is briefly described in Section S.5.

DOE is responding to its own need to make a decision on the HFBR's future, as well as responding to Congressional direction to prepare an EIS. The Conference Report accompanying Public Law 105-62, the *Energy and Water Development Appropriations Act* of 1998, directed that an EIS be prepared on the HFBR. The Report noted the conferees' expectation that the EIS include a "comprehensive survey of any environmental hazards that the tritium leak or other contamination associated with the HFBR pose to the drinking water and health of the people in the surrounding communities, and that it will provide a detailed plan for remediation."

Figure S.2-1. Location of Brookhaven National Laboratory on Long Island.



S.2.1 CERCLA OPERABLE UNIT III SUMMARY

After completion of the initial investigation, DOE decided that the public concerns about the tritium plume should be addressed in the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) Operable Unit (OU) III Remedial Investigation/Feasibility Study (RI/FS). Data collected on groundwater flow indicate that tritium concentrations greater than the drinking water standard, given that no more tritium would be leaking from the spent fuel pool, will not cross the BNL boundary from the HFBR tritium plume due to natural decay and dilution.

In March, 1999, DOE announced a public comment period on BNL groundwater cleanup documents for OU III; the Remedial Investigation (RI) Report, Feasibility Study (FS), and the *Proposed Plan for Operable Unit III*. These documents address cleanup of groundwater contamination both on and off the BNL site.

The FS addresses remediation of tritium and other contaminants. Cleanup objectives include: meeting drinking water standards in groundwater for tritium and other contaminants; completing cleanup of groundwater in a timely manner; and preventing or minimizing further migration of contaminants.

The *Proposed Plan for Operable Unit III* identifies proposed remedies for the groundwater contamination. Since the tritium is expected to decay to levels below the drinking water standard before reaching the site boundary, monitored natural attenuation is proposed. The existing tritium pumping system that was started in 1997 would be placed in standby. This system would be restarted if monitoring of the tritium plume indicates that concentrations of tritium above the drinking water standard could migrate offsite. Additional low-flow extraction wells would be installed near the HFBR and operated if tritium concentration levels adjacent to the HFBR increase significantly due to migration of tritium

out of the soil beneath the HFBR. Groundwater monitoring would continue.

Proposed remedies may be modified or different removal/remedial actions may be selected based upon public comments. After consideration of public comments, DOE, U.S. Environmental Protection Agency (EPA), and New York State Department of Environmental Conservation (NYSDEC) will make a final decision on the OU III cleanup remedies. The decision will be formalized in a ROD, and remediation work will be conducted under the framework of an interagency agreement among the DOE, EPA, and NYSDEC.

S.3 THE DECISION PROCESS

S.3.1 THE NEPA PROCESS

In preparing this DEIS, DOE is complying with the provisions of the *National Environmental Policy Act* (NEPA) (42 United States Code [USC] 4321 *et seq.*). NEPA requires Federal agencies to prepare detailed statements for “major Federal actions” (proposed actions) with the potential to significantly affect the human environment (NEPA Section 102(2)(C)). Among other things, environmental impact statements (EISs) are to include the environmental effects of the proposed action and alternatives to that action.

Requirements for the preparation of EISs are contained in the President’s Council on Environmental Quality (CEQ) *Regulations For Implementing the Procedural Provisions Of NEPA* (40 Code of Federal Regulations [CFR] 1500-1508). DOE has also prepared NEPA implementing procedures (10 CFR Part 1021) to complement the CEQ regulations. DOE Field Organizations and Program Offices are required to follow the DOE and CEQ regulations when conducting environmental impact analyses under NEPA.

Prior to preparing the DEIS, the CEQ regulations require Federal agencies to solicit public input concerning the scope of the analysis to be performed. This process is called

“scoping.” Using the information gained from scoping, DOE prepared this DEIS. The public is invited to comment on the DEIS. Meetings will be held in the fall of 1999 at Berkner Hall at Brookhaven National Laboratory.

In 1997, DOE issued its *Action Plan for Improved Management of Brookhaven National Laboratory*, which summarized DOE’s planned process for deciding the future of the HFBR. The Action Plan states that the Secretary of Energy will decide the future of the HFBR and directs an appropriate environmental review process. That review process includes this DEIS on the HFBR. The Secretary is scheduled to select a preferred alternative for the future of the HFBR in late 1999. The preferred alternative, which will be included in the Final HFBR EIS (FEIS), will take into account several factors, including the analysis of environmental impacts contained in this DEIS, public input from the local Long Island community, input from the HFBR scientific-user community and the DOE Basic Energy Sciences Advisory Committee, and the value of the scientific information produced using the HFBR.

Public comments regarding the content of this DEIS will be used to make necessary revisions. After any revisions are made, the FEIS will be made available to the public. A notice will be published in the *Federal Register* announcing the availability of the Final EIS. No sooner than 30 days after the FEIS Notice of Availability, the Secretary will make a decision regarding the future of the HFBR. That decision will be presented in a Record of Decision (ROD), which also will be published in the *Federal Register*.

S.3.2 PUBLIC INVOLVEMENT

On November 24, 1997, DOE published a Notice of Intent (NOI) in the *Federal Register* to prepare an EIS pursuant to NEPA for the HFBR at BNL (62 FR 62572). Publication of the NOI marked the beginning of the EIS scoping process. Three scoping meetings were held in the vicinity of BNL to receive public input about the scope of the EIS and to identify the issues of greatest concern. The meetings were held on

December 10, 1997, January 10, 1998, and January 15, 1998. The scoping period closed on January 23, 1998.

DOE received nearly 600 comments during this scoping process. All comments were reviewed to identify environmental issues for assessment in the EIS. Significant issues are discussed in the next section of this summary. A report summarizing the public scoping process and relevant issues identified for analysis was prepared by DOE. This report is available for review, along with all public comment letters, e-mail, facsimiles, telephone comments and scoping meeting transcripts, at the following public reading rooms: Building 477A Brookhaven Ave. at BNL, Longwood Public Library in Middle Island, Mastics-Moriches-Shirley Community Library in Shirley, Patchogue-Medford Library in Patchogue, and the DOE Forrestal Building at 1000 Independence Ave SW in Washington, D.C.

S.3.3 SIGNIFICANT ISSUES FOR ANALYSIS

The most significant issues raised during the scoping process relate to human health and safety, water resources, socioeconomics, and waste management.

Public concerns regarding human health and safety were primarily related to the potential adverse effects of long-term exposure to low-level concentrations of tritium in drinking water supplies. Other concerns related to the epidemiological studies and data that address potential adverse health effects (including rhabdomyosarcoma and breast cancer) in nearby offsite populations. The socioeconomic issues raised relate to job creation or loss from restart or shutdown of HFBR. Waste management issues concerned the generation, storage, and disposal of HFBR wastes. Potential adverse effects from offsite transportation of waste for disposal also was raised as an issue needing analysis in the EIS.

These issues are addressed in the respective sections (Public and Occupational Health and

Safety, Water Resources, Socioeconomics, and Waste Management) of this EIS.

The leak of tritium from the HFBR spent fuel storage pool to groundwater is a major concern. Several interest groups and political figures have expressed opposition to operation of the HFBR, and in 1998 and 1999 Congress prohibited the use of funds for the restart of the HFBR.

In compliance with the CEQ regulations, comments received on this DEIS will be assessed and considered both individually and collectively (40 CFR 1503.4). DOE's responses to comments received may involve modification of alternatives or development and evaluation of new alternatives, modification of the analysis, factual corrections of the DEIS text, or an explanation of why a comment may not require a response. All substantive comments (or summaries of them) received on this DEIS will be attached to the FEIS whether or not the comment is discussed in the FEIS text. Following the completion of the FEIS, a public notice will be given in the *Federal Register* to announce the availability of the FEIS. DOE must wait a minimum of 30 days after this notice before issuing a ROD concerning the future of the HFBR at BNL.

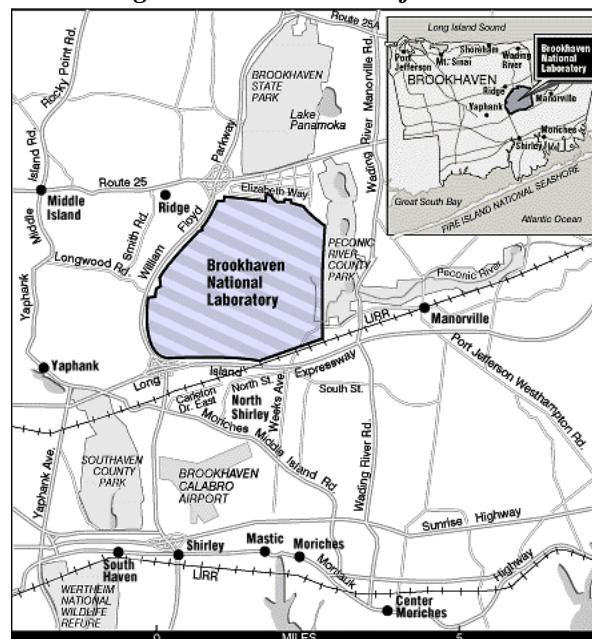
S.4 THE HFBR AND PHYSICAL PLANT

BNL was established in 1947 as a national research center for the peaceful uses of atomic energy. BNL is located on a former Army base known as Camp Upton, which was declared surplus at the end of the Second World War. BNL encompasses approximately 2,150 hectares (ha) (5,300 acres) (See Figure S.4-1). Most facilities at BNL are located near the center of the site (see Figure S.4-2).

When BNL opened in January 1947, it was one of three federally funded facilities designed to conduct nuclear research beyond the resource capabilities of individual universities. Much of this research was performed using nuclear reactors and particle accelerators. Today, BNL has four core missions: designing, building, and

operating research facilities, scientific research, technology development, and knowledge transfer.

Figure S.4-1. Location of BNL.



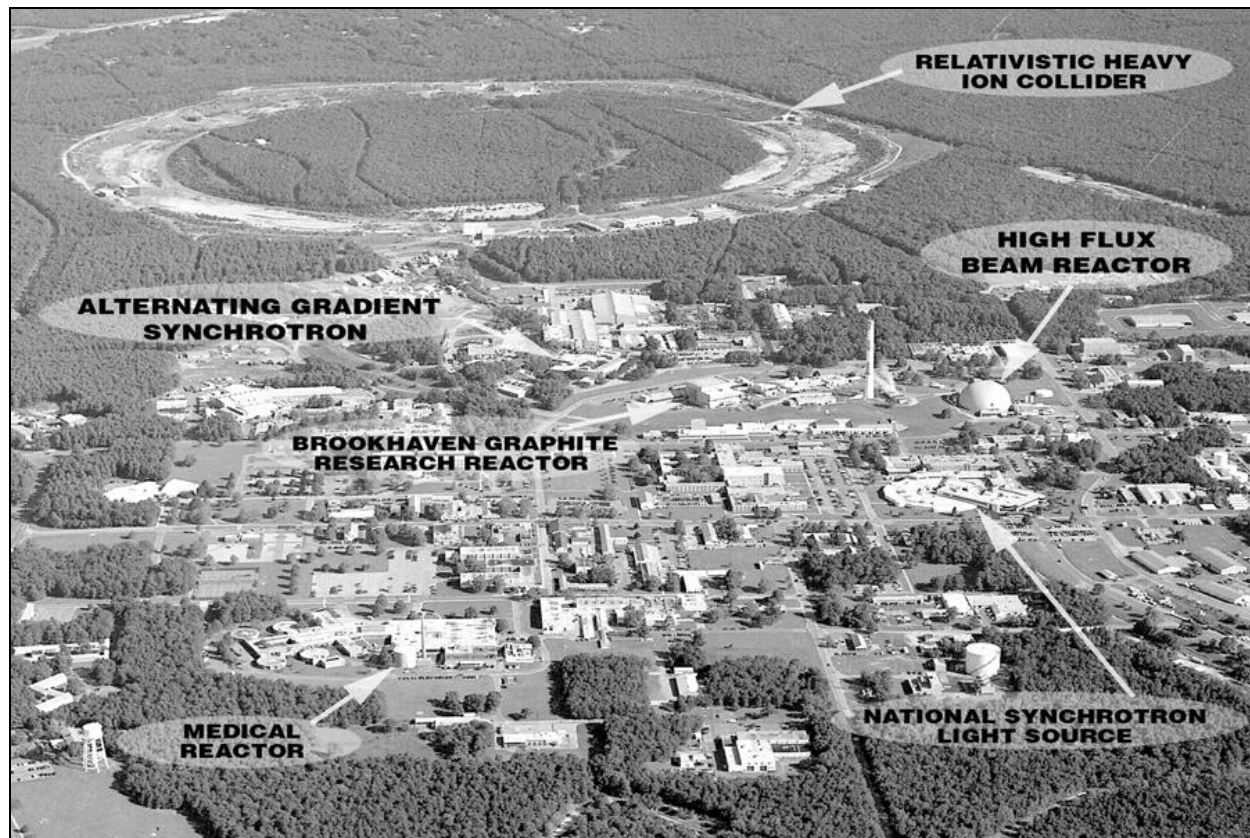
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Note: This figure is oriented so that the top of the figure is north.

The HFBR has been used since 1965 as a scientific facility dedicated to neutron scattering research and other research programs. Neutron scattering techniques are used to study the structure and properties of materials. The HFBR has provided about two-thirds of DOE's experimental capability at reactors for neutron scattering. The entire reactor and its control room are enclosed within a confinement dome, as shown in Figure S.4-3. The reactor has been used exclusively for research and does not produce electric power. The reactor has not been used for any weapons-related research, and such use is not contemplated.

The HFBR uses heavy water (deuterium oxide, or D_2O , which is water whose hydrogen atom has an extra neutron in its nucleus) for cooling and a highly enriched uranium (HEU) (U^{235}) core to produce beams of thermal neutrons that are guided to experimental areas by nine horizontal aluminum alloy tubes called "beam tubes." The core consists of 28 fuel elements; each element contains 18 curved fuel plates. In

Figure S.4-2. BNL Facilities.



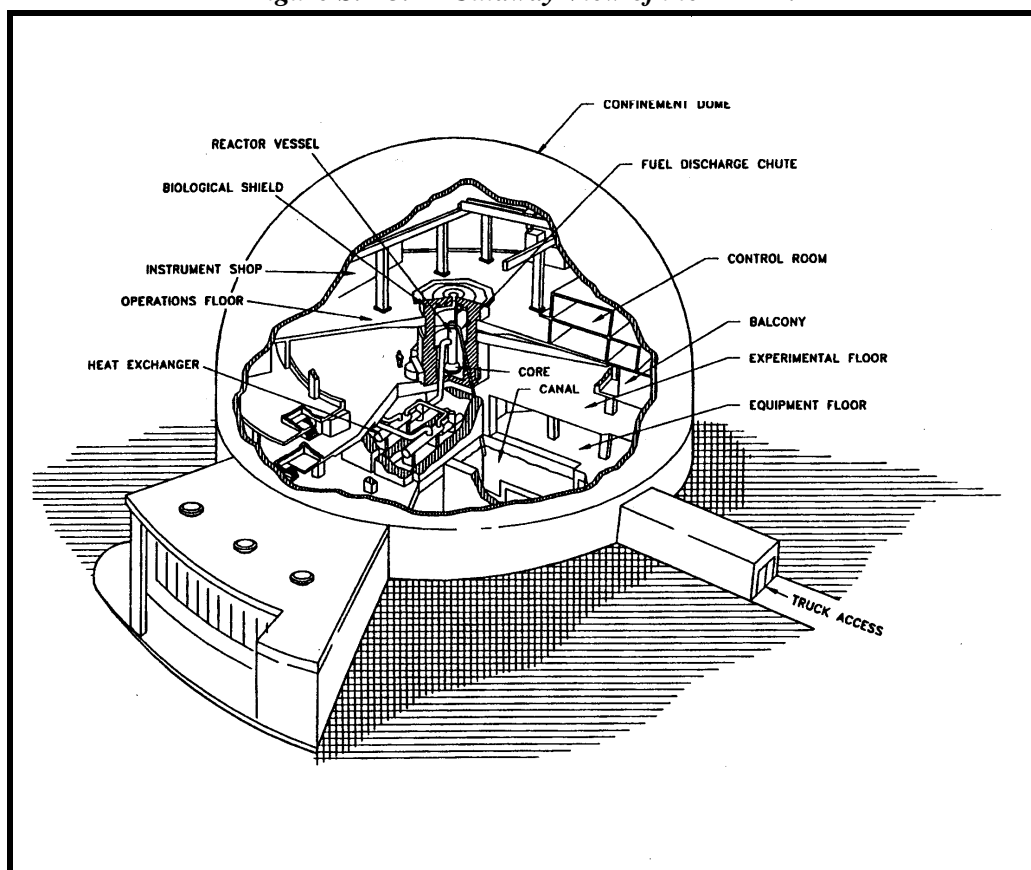
each plate, uranium oxide powder is mixed with aluminum powder to form a core — known as a cermet core — which is then encased in an aluminum cladding. The cladding acts as a barrier or containment for the radioactive isotopes formed as fission by-products of the controlled nuclear chain reaction. Once the useful energy has been extracted from the fuel through the controlled nuclear reaction, the fuel becomes spent nuclear fuel (SNF), which is transported to DOE's Savannah River Site (SRS) for storage pending disposition.

The entire core is about the size of a small refrigerator. The D_2O is pumped downward through the spaces between the fuel element plates carrying away the heat that develops in the core. The D_2O is circulated through a pair of heat exchangers where the heat is transferred to a light water (H_2O) secondary loop (the water is obtained from onsite wells and recirculated through the system) which dissipates the heat

into the air through a set of cooling towers. In a standard power reactor, which is typically operated at power levels approximately 100 times greater than the HFBR, it is this heat which is used to produce steam to drive turbines that produce electricity. However, this is a research reactor, geared to the production of neutrons. The HFBR's operating temperature is close to 60° Celsius (C) (140° Fahrenheit [F]), considerably cooler than a commercial power reactor.

The HFBR was originally designed and built to operate at a power level of 40 megawatts (MW). An equipment upgrade in 1982 allowed operation at 60 MW, which greatly enhanced the reactor's scientific capability. In 1988, the National Academy of Science/National Research Council issued a report on safety issues at DOE test and research reactors. The report noted that potential dose rates from a hypothetical HFBR loss of reactor coolant accident at 60 MW and

Figure S.4-3. A Cutaway View of the HFBR.



exposure to operators during such an event were not adequately addressed. The HFBR was shut down to address this issue. In 1991, after several analyses with different experts, a conservatively determined power level of 35.4 MW was set below which fuel damage leading to exposure of operators would not occur. To provide an additional margin of safety, DOE authorized operation of the HFBR at 30 MW. Subsequent analyses indicated that the HFBR could be safely operated at 60 MW (BNL 1997, DOE 1998). Scientific users, which consist of national and international academic and industrial researchers, have recommended operating the reactor at 60 MW, and requested that the DOE upgrade and modernize the scientific instrumentation and other features such as the beam tubes.

S.5 ALTERNATIVES ANALYZED IN THE HFBR EIS

DOE has identified four alternatives for the future of the HFBR. They are:

- 1) No Action Alternative
- 2) Resume Operation Alternative, which has two subalternatives to operate at either 30 MW or 60 MW
- 3) Resume Operation and Enhance Facility Alternative
- 4) Permanent Shutdown Alternative.

Regardless of which alternative is selected, DOE will comply with the provisions of Suffolk County Sanitary Code, Articles 7 and 12, and will take action to prevent and protect against any unplanned releases of tritium that might contaminate the environment. It is the intent of

Suffolk County Sanitary Code, Articles 7 and 12, to safeguard all water resources of the County of Suffolk from toxic or hazardous materials pollution, especially in deep recharge areas and water supply sensitive areas. The modifications that are being made to the HFBR in order to comply with Suffolk County Sanitary Code, Articles 7 and 12, which are expected to be completed in spring of the year 2000, are discussed in Section S.6.

S.5.1 NO ACTION ALTERNATIVE

Under this alternative, the HFBR would be maintained in the current shutdown and defueled condition for the indefinite future. DOE regards this as a non-preferred alternative because it does not resolve the future of the HFBR.

Spent fuel elements have been removed from the spent fuel pool and shipped to the SRS for storage pending disposition; the final shipment was in September 1997. Water from the pool has been transferred to storage tanks via existing double-walled piping used for routine transfers of radioactive water from the HFBR to the waste management facilities. The modifications described in Section S.6 have been or will be performed. This is the reactor configuration against which the other alternatives will be compared in the following sections. The CEQ regulations require that the No Action Alternative be considered for all EISs. The No Action Alternative may or may not be a reasonable alternative.

S.5.2 RESUME OPERATION ALTERNATIVE

This alternative includes two subalternatives.

S.5.2.1 30 MW Operation

Restart and operation of the reactor at a power level of 30 MW. This power level would be the same as the reduced level maintained before the shutdown.

S.5.2.2 60 MW Operation

Startup and operation of the reactor at a power level of 30 MW with a planned increase in operation of up to 60 MW. The HFBR has operated previously at 60 MW. No physical modification of the HFBR facility is required to change from 30 MW operation to 60 MW operation.

S.5.3 RESUME OPERATION AND ENHANCE FACILITY ALTERNATIVE

Under this alternative, DOE would resume operation of the reactor at a power level of up to 60 MW and eventually the facility's scientific capabilities would be upgraded. This could entail the addition of scientific instruments, as well as replacement of the reactor vessel and its beam tubes. Replacement of the reactor vessel and its beam tubes will also extend the useful life of the HFBR.

The following is a short list of the possible enhancements of the HFBR under this alternative:

- Reactor vessel and associated beam tube replacement
- Cold Neutron Facility enhancement within the reactor vessel
- Scientific research instrumentation upgrade
- Thermal shield replacement

Operation of the HFBR at 30 MW or 60 MW would not be affected by the implementation of these enhancements. It should be noted that, because of budget limitations, DOE regards the Resume Operation and Enhance Facility Alternative as a non-preferred alternative.

S.5.4 PERMANENT SHUTDOWN ALTERNATIVE

Under this alternative, the HFBR would be permanently shutdown for eventual decontamination and decommissioning (D&D). Since D&D is the final outcome of any reactor

facility, it will eventually be necessary under any alternative. The fact that D&D is discussed under the Permanent Shutdown Alternative does not mean that D&D is not an eventual consequence in other alternatives; rather, it indicates that D&D would likely occur sooner should the Permanent Shutdown Alternative be selected by DOE. Additional environmental review would be necessary in the future to perform the D&D of the reactor. This alternative would involve terminating the scientific research mission of the HFBR and placing the reactor in an industrially and radiologically safe condition for an extended period of time. This would be followed by D&D when funding is provided by Congress. While an analysis of the full and complete D&D is beyond the scope of this EIS, the potential environmental impacts associated with D&D are analyzed to the extent practical.

S.6 MODIFICATIONS TO THE HFBR

Regardless of the alternative chosen by DOE, the following specific repairs and modifications have been or will be made at the HFBR in order to comply with Suffolk County Sanitary Code, Articles 7 and 12. These repairs and modifications will also enhance the integrity of structures required to assure environmental protection should a design-basis earthquake occur and ensure that there is no future tritium leakage to groundwater. These repairs and modifications are expected to be completed in the spring of the year 2000.

S.6.1 FLOOR JOINTS AND PENETRATIONS

Floor joints and penetrations (including conduit, water and gas pipes, and other penetrations) in the floor of the HFBR have been repaired and sealed to ensure that there is no leakage path to groundwater from any accidental spill within the reactor confinement building. The potential for spills exists during both reactor operations and deactivation activities when there would be a

need to move large quantities of radioactive liquids into tanks and drums for storage, treatment, or disposal.

S.6.2 PIPING SYSTEMS AND SUMPS

Piping systems and sumps in the HFBR that may potentially leak to the environment will be modified and repaired by replacing single-walled piping and sumps with double-walled components, or installing new components above the floor, to meet the requirements of Suffolk County Sanitary Code, Articles 7 and 12 for protection of groundwater. These systems would be used during operations and during deactivation activities to flush systems and reduce contamination.

S.6.3 STACK DRAINS

The drains from the 106 meter [m] (350 foot [ft]) tall stack — which handles exhaust gases from the HFBR and other nearby facilities — will be repaired, along with the collection piping and sump, to convert them from single-walled to a double-walled system. This would enhance the confinement integrity of the HFBR by providing a barrier against potential accidental release of radioactive materials to groundwater.

S.6.4 SEISMIC REINFORCEMENT

The HFBR control room and operations level crane will be reinforced to protect radiological monitoring and control systems, as well as operations personnel, in the event of a design-basis earthquake. The control room and crane are needed to ensure safe reactor operations or deactivation activities. The crane is used primarily for moving large shielding blocks, heavy-shielded casks, and miscellaneous heavy equipment associated with the reactor and operations-level equipment. The crane would be used for similar purposes during deactivation activities.

S.6.5 SPENT FUEL POOL LINER SYSTEM

A double-walled stainless steel liner will be constructed and installed in the spent fuel pool. The installation of this impervious liner and appurtenant piping and leak detection system would result in the secondary containment of the HFBR spent fuel pool to ensure that the spent fuel pool would not be a source of groundwater contamination in the future. The spent fuel pool would be used for the temporary storage of radioactive components such as control rod blades under the No Action Alternative, would be needed to store spent fuel during operations should the reactor be restarted, and would be used to contain various radioactive reactor components which must be dismantled or cut apart in preparation for shipment offsite in the eventual D&D activities.

S.7 AFFECTED ENVIRONMENT

The Affected Environment section of this DEIS presents a description of the conditions of the environment at BNL. The current condition is termed the “baseline,” and is used as the benchmark for comparison of the predicted potential impacts of implementing the DEIS alternatives. The presentation of the Affected Environment is organized into descriptions of biological, physical, and sociocultural (socioeconomic and cultural) resources as well as other factors that comprise the human environment. For the purposes of this DEIS, the term “resource” is used to describe environmental resources as well as the other factors (for example, infrastructure, noise, occupational health, and the visual environment).

S.7.1 LAND USE/VISUAL RESOURCES

Land Use: Land use adjacent to the BNL facility includes a mixture of residential, commercial/industrial, institutional, preserved

open space, and vacant land. The HFBR is located in an area of the BNL site designated as Industrial/Commercial. This area is where the majority of BNL’s buildings are located.

Visual Resources: From the air, the hemispherical dome of the reactor building and the 106 m (350 ft) stack are recognizable features of the BNL landscape. At the property line, none of these facilities is visible from ground level. This visual buffer is a result of the HFBR’s distance from the property line as well as the presence of a thick line of trees around the property. The stack is visible from some elevated areas offsite as well as from long distances, such as from a boat off the Long Island shore. There was no visible plume from the stack when the HFBR was in operation.

S.7.2 INFRASTRUCTURE

Development of the BNL site has been influenced by the buildings and utilities inherited from the former Camp Upton. The general location and arrangement of the roads, buildings, and utilities are a legacy of this former U.S. Army camp. The physical plant has been upgraded gradually over the last 51 years, but many of the original Army elements are still used and will continue to be accommodated in future planning.

To support missions at BNL, water is pumped from onsite supply wells, and after any required treatment, is used for either potable or process needs. Water is used at the HFBR for facility air conditioning, fire sprinklers and standpipes, secondary water system makeup, normal staff use, and miscellaneous plant equipment makeup and cooling.

The sewage system consists of approximately 50 km (30 mi) of piping, most dating back to World War II. There is an ongoing major project to upgrade this piping. A new sewage treatment plant with a 6 million liters (1) per day (MLD) (1.5 million gal per day [MGD]) capacity has been constructed and opened in December 1997. This plant supplements the existing sewage

treatment plant that has an 11 MLD (3 MGD) capacity.

Electricity is purchased from the New York Power Authority and the Long Island Power Authority. The current peak demand of 54 megawatts, electric (MWe) is expected to increase to 75 MWe by the year 2000. BNL has two main substations for stepping down the power from 69 kilovolts (kV) to 13.8 kV.

Steam for site heating and other requirements is produced in a central steam facility. This facility contains four boilers with a combined capacity of approximately 180,000 kilograms (kg) per hour (400,000 pounds per hour) of steam. No. 6 fuel oil (approximately 19 million l per year [5 million gal per year]) purchased from a commercial fuel supplier was the primary fuel source to fire the boilers in the past; however, a natural gas connection was recently established for this purpose. Natural gas is purchased from Brooklyn Union Gas. A reduced amount of No. 6 fuel oil (about 10 percent of past years' consumption) continues to be used.

S.7.3 AIR QUALITY/NOISE

Air Quality: The New Jersey-New York-Connecticut Interstate Air Quality Control Region, which includes Suffolk County and BNL, is in attainment with most National Ambient Air Quality Standards (NAAQS) for criteria pollutants, which include sulfur dioxide, nitrogen oxides, particulate matter, lead, and carbon monoxide. The region exceeds the NAAQS for ozone.

The site, similar to the region and most eastern seaboard areas, can be characterized as being a well-ventilated site. The prevailing ground level winds are from the southwest during the summer, from the northwest during the winter, and about equal from these two directions during the spring and fall.

Noise: The day-night average sound level (dBA) is the composite measure of noise during a 24-hour period with 10 decibels (dB) added to nighttime levels (between 10 p.m. and 7 a.m.).

This adjustment is added to account for the increased sensitivity to nighttime noise events. A background sound level of 30 dBA is a reasonable estimate for the surrounding area. This is consistent with other estimates of sound levels for rural areas. The rural communities day-night average sound level has been estimated in the range of 35 to 50 dBA. A background sound level of 50 dBA is a reasonable estimate for the main BNL facility.

S.7.4 WATER RESOURCES

Water resources include surface waters and groundwater potentially impacted by operation of the HFBR. Surface water includes freshwater bodies that occur above the surface of the ground, including rivers, streams, lakes, and human-created catchment basins (recharge basins). Groundwater resources are defined as the aquifers underlying the site and region.

Streams and Ponds: BNL is located entirely within the Peconic River watershed. The Peconic River is a low-gradient stream that has a relatively undeveloped watershed. It is the largest groundwater-fed river in New York and the longest river on Long Island. The western headwaters of the Peconic River originate approximately 1.2 km (0.75 mi) west of the site and the river flows east to Peconic Bay. Portions of the river were designated as a Wild, Scenic and Recreational River by the State of New York in 1986 because it represents the last significant undeveloped river within the Long Island Pine Barrens area. Stream flow in the Peconic River is heavily influenced by groundwater level, with discharge of groundwater through the stream bed during periods of high rainfall, and infiltration of stream flow into the stream bed during periods of low rainfall.

A branch of the Peconic River headwaters enters the BNL property in the northwest portion of the site. The river exits the site to the southeast near North Street. Within the site boundaries, the Peconic River is an intermittent stream and typically has little or no flow. Offsite flow occurs during periods of sustained precipitation,

typically in the spring. The start of flow for the Peconic is typically to the east (downstream) of the site boundary. The BNL Sewage Treatment Plant (STP) has a State Pollutant Discharge Elimination System (SPDES) permitted discharge on the Peconic River approximately 2,400 m (1.5 mi) upstream of where the river exits the site (SPDES Permit # NY 0005835, Outfall 001, Location EA). This outfall receives wastewater from the HFBR. Section S.8.2.2 provides further discussion of waste minimization. The only natural pond onsite is Zeeks Pond located along the eastern site boundary.

Recharge Basins: BNL maintains seven recharge basins, which are permitted under SPDES, for the discharge of process cooling waters, stormwater runoff, and water-filter backwash from the Water Treatment Plant. Water entering the recharge basins infiltrates back into groundwater, replenishing the underlying aquifers.

Groundwater: Aquifers located on Long Island are classified as Sole Source (Class I) aquifers by the EPA (42 USC 300h-3(e)) and as Class GA (potable water) by NYSDEC. Groundwater is the sole source of potable water for Suffolk County residents. Long Island's groundwater reserve originates from precipitation percolating downward to the underlying aquifers. Groundwater levels vary across Long Island due to seasonal variations in recharge from precipitation and the rate of evapotranspiration. Approximately 85 percent of County residents obtain their potable water from private water supply companies; the remaining population is served by individual private wells. While there is no HFBR-related contamination of offsite wells, DOE has provided public water hookups for area residents that may potentially be affected by other historic BNL activities. More information about those historic non-HFBR activities affecting groundwater can be found in Section 3.5 of the DEIS.

The hydrogeology in the vicinity of the BNL site consists of approximately 460 m (1,500 ft) of unconsolidated sediment overlying bedrock. These unconsolidated deposits consist of the

Upper Glacial Aquifer, Gardiners Clay, the Magothy Aquifer, Raritan Clay, and the Lloyd Aquifer. Bedrock lies under these deposits.

S.7.5 GEOLOGY/SEISMICITY

Geology: BNL is in the upper part of the Peconic River Valley, which is bordered by two lines of low hills. These hills extend east and west beyond the limits of the valley nearly the full length of Long Island and form its most prominent topographic features.

Six principal stratigraphic units, some of which include subdivisions of minor importance, were recognized in test drilling at BNL. The soils at BNL are predominately coarse, sandy soils derived largely from glacial outwash materials including the Ronkonkoma moraine.

Seismicity: Long Island lies in a zone 2 ("moderate damage") seismic probability area. It is assumed that an earthquake of intensity VII (Modified Mercalli) could potentially occur. No active earthquake-producing faults are known in the Long Island area. The most recent recorded earthquake with observable effects occurred on October 19, 1985. This event was approximately 69 km (43 mi) west of BNL in White Plains, New York and had a Modified Mercalli Intensity of V which produced ground acceleration at least ten times less than the design standard for BNL's reactor buildings and associated structures.

The probability of occurrence in the BNL area of an earthquake sufficiently intense to damage buildings and reactor structures was thoroughly investigated during the preparation of the *Final Safety Analysis Report* for the HFBR. Additional analyses were conducted using a "design basis earthquake" producing ground acceleration of 0.2 g during the preparation of the *Draft Safety Analysis Report Upgrade* for HFBR. Although these analyses showed no damage to the reactor itself, reinforcement of the control room housing radiological monitoring and control systems was determined to be necessary. Section 2.3 of the HFBR DEIS discusses those planned reinforcements.

S.7.6 ECOLOGICAL RESOURCES

A total of 15 ecological communities have been identified on or within 0.8 km (0.5 mi) of the BNL property. The dominant ecological community is shared by pine/oak forest and deciduous forest. The greatest number and diversity of wildlife species of any of the communities has been observed in the pitch pine/oak community. White-tailed deer, gray squirrel, cottontail, and chipmunk are common. Birds sighted included blue jay, downy and hairy woodpeckers, northern orioles, mourning dove, gray catbird, rufous-sided towhee, and warblers.

Disturbed or developed areas are located in the central and southern parts of the BNL complex, including the HFBR site. These areas include buildings, paved areas, small patches of forest, lawn area, and plowed, planted fields. Due to development, human activity, and broken, discontinuous habitat, the wildlife using this community consists chiefly of species tolerant of humans. Vegetative communities are represented by lawn, shrub/sapling community, patches of predominantly deciduous forest, and plantings of nonnative grasses/crops, shrubs, and trees.

A total of four wetland communities were identified in the study area. Extensive forested wetlands mapped by NYSDEC and the National Wetland Inventory are found in the northern and eastern areas of the site. The pine barrens shrub/sapling wetlands are located on the northern portion of BNL and associated with the headwaters of the Peconic River. Herbaceous wetlands, also present on the northern portion of the BNL site and associated with the headwaters of the Peconic River, are generally found where a prolonged period of inundation or saturation prevents growth of a forested or shrub community. Lacustrine wetlands are found only in the open-water environment of Grassy Pond, northeast of BNL but within the 0.8 km (0.5 mi) study area.

A total of four aquatic communities were identified in the study area. Retention basin (or

water recharge basins) are defined as constructed depressions near a road or development that receive stormwater or industrial runoff and allow water to percolate through (or “recharge”) into the groundwater. The 11 coastal plain ponds found in the northern portion of BNL and within the study area are naturally occurring ponds with permanent standing water or constructed ponds within the particle accelerator ring. The coastal plain streams are found throughout the north-south drainage of the Peconic River basin to Horn Pond, east of the BNL. Sewage treatment ponds are the aeration and settlement ponds that release effluent from the BNL filtration plant to the Peconic River, and is one of the least common communities identified in the BNL area.

S.7.6.1 Threatened and Endangered Species

Various State and Federally protected wildlife species were observed on the BNL site in 1994, including eastern tiger salamander (State endangered), osprey (State threatened), and common nighthawk, eastern bluebird, spotted turtle, spotted salamander, and eastern hognose snake (special concern species). Onsite breeding areas were confirmed for the tiger salamander during a species-specific study.

Five plant species and eight fern species found onsite are classified as protected plants under New York State law. The plant species found were the butterflyweed, spotted wintergreen, lady's slipper, bayberry, and flowering dogwood. The eight species of protected ferns found were hayscented fern, shield fern, sensitive fern, cinnamon fern, Clayton's fern, royal fern, marsh fern, and Virginia chain fern. In addition, one protected plant species, drowned horned rush, is reported by the Natural Heritage Program to occur in the site vicinity but has not been identified onsite.

S.7.7 CULTURAL RESOURCES

The Deputy Commissioner for Historic Preservation of the New York State Office of Parks, Recreation, and Historic Preservation

issued a determination on April 2, 1991 that only three areas of the BNL site were recommended for preservation activities: the Graphite Reactor Building (Building 701), the Old Cyclotron Enclosure (Building 902), and a small area of World War I era trenches (approximately 30 m by 30 m [100 ft by 100 ft]). None of these three culturally significant areas are impacted by the HFBR. No other areas at BNL are eligible for inclusion in the National Register of Historic Places. To date, no paleontological remains have been discovered at BNL.

There are two Long Island tribes recognized by the State of New York, the Shinnecocks in Southampton and the Poospatucks in Mastic. The Montaukett Indians from the South Fork area are not formally recognized by the State of New York, but are asking for formal recognition from the Federal government. At this time none of the Native American groups on Long Island have received Federal recognition. To date, there are no known traditional cultural properties located on or near BNL.

S.7.8 SOCIOECONOMICS

For purposes of the DEIS analysis, the BNL Region of Influence (ROI) is a two-county area on Long Island consisting of Nassau and Suffolk Counties. Although the ROI is well developed, it contains no major cities.

BNL exerts an important influence on the regional economy. During Fiscal Year 1998, BNL employed approximately 3,100 permanent workers. In addition, BNL hosted 3,200 temporary workers, primarily visiting scientists. There has been little or no effect to the site's permanent workforce, which is expected to remain stable through the year 2000, as the result of the HFBR being shutdown.

BNL has a budget of \$400 million, and through secondary effects of BNL spending, the total effect of BNL on the Long Island economy is estimated at approximately \$1 billion.

The ROI unemployment rate was 4.2 percent in 1996, the lowest level since 1990. The

unemployment rate was 4.7 percent in Suffolk County compared to 3.8 percent in Nassau County. Slow but stable growth is projected through 2010.

S.7.9 TRANSPORTATION

The maximum total number of BNL personnel involved in working at the HFBR is approximately 130, therefore, the maximum number of vehicles traveling to and from BNL as a result of the HFBR is 130. This number in all likelihood overestimates traffic to and from BNL because it does not account for car pooling or the fact that there is onsite housing.

During years that the HFBR was operated, spent fuel from the HFBR was shipped in U.S. Department of Transportation/U.S. Nuclear Regulatory Commission/DOE approved shipping casks. Periodically, reactor vessel components and internal parts were replaced and were stored in the spent fuel pool. These materials were shipped offsite in casks along with the spent fuel element shipments. To address spent fuel shipments, BNL prepared alternative route studies (ADL 1984) and a spent fuel transportation plan (DOE 1997). The route studies analyzed the use of Department of Transportation approved routes from BNL to DOE storage sites. The transportation plan included operations and contingency plans for the shipments.

While there are currently no HFBR spent fuel elements onsite at BNL, typically spent fuel elements were shipped once every several years in a single shipping campaign. Depending on the power level at which the HFBR was operating, a shipping campaign would be expected once every three to five years.

S.7.10 PUBLIC AND OCCUPATIONAL HEALTH AND SAFETY

Public and occupational health and safety issues include the determination of potentially adverse effects on human health and safety that result from acute and chronic exposures to ionizing radiation and hazardous chemicals. The degree of hazard is directly related to the type and

quantity of the particular radioactive or chemical material to which the person is exposed and to the duration of this exposure. The acute or chronic radiological exposures have been converted to potential cancers and noncancer effects. This is done for both normal operations and theoretical accident situations.

Table S.7-1 characterizes the radiation exposures to Long Island residents in 1995. The table also displays the operational characteristics of the HFBR in 1995, when it was operating at 30 MW.

S.7.10.1 Radiation in the Environment

Table S.7-1 also summarizes the major sources of radiation exposure in the vicinity of the HFBR. Releases from the HFBR constitute an extremely small fraction (much less than 0.1 percent) of the total natural and other background exposure to the public in the vicinity of the reactor.

In 1995, air sampling was performed throughout the year to monitor airborne radionuclide concentrations. Monitoring was performed for

the analysis of particulates, radioiodines, and tritiated water (HTO) vapor. Naturally occurring radionuclides and tritium were detected most frequently in the collected samples. Gross alpha and gross beta activity levels were consistent with those measured in Albany, NY, a location used as a control area by the New York State Department of Health (NYSDOH) in their state-wide environmental radiation monitoring program.

In 1997 when the HFBR was shutdown, 27 Curies (Ci) of airborne HTO were released from the HFBR. While this constituted the second largest source of total airborne activity released from BNL, tritium contributed less than one percent of the total offsite population dose from all BNL sources (0.098 person-rem per year and 3500 person-rem per year, respectively). Tritium is a naturally occurring isotope of hydrogen. Most tritium, however, is artificially produced in nuclear reactors. It has the same chemical properties as hydrogen but it is radioactive. Because it is an isotope of hydrogen, it is easily incorporated into water in the atmosphere and may return to the earth's surface as rain or snow.

Table S.7-1. Sources of Radiation Exposure to Long Islanders in the Vicinity of the HFBR

Source	Average Dose to an Individual (mrem/yr)	Total Exposure (percent)
Natural Background		
Cosmic	24	6.6%
External	36	9.9%
Internal	40	10.9%
Radon	200	54.8%
Total Natural	300	82.2%
Other Background		
Diagnostic X-ray	53	14.5%
Weapons test fallout	<1	0.2%
Air Travel	1	0.3%
Consumer products	10	2.8%
Total Other	65	17.8%
HFBR	1.9×10^{-6}	<<0.1%
TOTAL	365	100%

Note: < - less than, << - much less than

Tritium emits low-energy beta particles that cannot penetrate surfaces easily and can be stopped by skin, water, glass, aluminum and plastics. However, tritium can pose a health hazard if inhaled, swallowed, or absorbed through the skin. Tritium has a radioactive half-life of approximately 12.3 years. This means that in 12.3 years, half of the radioactive nuclei in any amount of tritium will change into stable, nonradioactive helium-3 (He^3). Tritium is a pure beta particle emitter, and the beta energy in tritium is very weak. If tritium gas is inhaled, only a small amount of the gas stays in the body because tritium is rapidly removed through exhalation. However, tritium atoms readily exchange with normal hydrogen in water and the tritiated water may be retained for longer periods in the body.

HTO interacts with the human body in the same manner as regular water. Whether in vapor or liquid form, HTO water can enter the body through inhalation, ingestion or absorption through the skin. Once inside the body, HTO is distributed throughout the body as regular water would be. HTO remains in the body a relatively short time and is eliminated in the same manner as regular water. Within 10 days, about half of the tritium that has entered the body is naturally eliminated.

Tritium would be released from the HFBR as follows. The HFBR would use heavy water to cool the reactor fuel and to control the neutrons produced and used in the fission process. Heavy water flowing through and around the fuel would be exposed to a dense neutron field, and tritium would be produced in the heavy water when deuterium nuclei absorb neutrons. The tritium concentration in the primary cooling water would be dependent upon the reactor power level, the number of days per year that the reactor is at power, and the amount of time elapsed since the last reactor shutdown or coolant change. This, in turn, would determine the amount of tritium that could be released as an airborne or liquid effluent. The primary means by which tritium would be transferred from the reactor coolant system to the atmosphere would be through the

depressurization of the reactor vessel and evaporative losses during maintenance and refueling operations. HTO would be released from the reactor system into the building air exhaust system where it would be routed to the facility's 106 m (350 ft) stack. For this reason, radiological impacts would not necessarily be greater for higher power operating levels (for example, 60 MW) than for the low power operating levels (for example, 30 MW). To keep tritium concentrations and releases as low as possible, the heavy water reactor coolant would be replaced periodically.

Other radionuclides would also be released from HFBR in very small quantities, typically in the microcurie (μCi) to millicurie (mCi) range. These radionuclides could be released through emissions from equipment such as the reactor vessel and storage tank cover gas vents. These releases would be within EPA National Emission Standards for Hazardous Air Pollutants (NESHAP) limits.

S.7.10.2 Chemicals in the Environment

As a research facility, the HFBR does not use a standard set of chemicals or quantities which are regularly present within the complex. With the exception of standard industrial processes, such as cooling water chemistry control, air conditioning, industrial solvents, and lubricants, most of the chemicals are used and stored in a laboratory setting, where relatively small quantities of hazardous chemicals are used on a non-production basis. Changing research requirements have in the past, and would in the future, necessitate the introduction of new substances. The hazards associated with each new chemical introduced to the HFBR complex would be evaluated on a case-by-case basis.

The chemical environment in the region surrounding BNL is described by the background chemical data obtained from soil samples which may be affected by BNL activities that may produce hazardous/toxic wastes. Although some chemicals are stored in levels above screening amounts, safety systems are in place to control potential hazards. No activity at the HFBR was found to use chemicals

Table S.7-2. Identification of Chemical and Other Nonradiological Hazards at the HFBR

Material	Regulatory Threshold	Screening Amount	Amounts Within the HFBR Complex
Chemicals			
Sulfuric acid	454 kg	230 kg	7,600 l (14,000 kg)
Secondary Water Corrosion Inhibitor ⁽¹⁾	11,300 l	5,650 l	7,600 l
Lithium Chromate Inhibitor	4.5 kg	2.2 kg	10 kg
Lithium Arsenite Inhibitor	0.45 kg	0.23 kg	3.6 kg
Cadmium Nitrate (in solution)	(2)	(2)	1,500 kg
(powder)	(2)	(2)	91 kg
Flammables and Explosives			
Propane	NA	NA	3,800 l
Beamline neutron detectors ³	NA	NA	Several
Hydrogen	NA	NA	Varied amounts
Welding gases	NA	NA	Varied amounts
Asphyxiants			
Fire suppression system	NA	NA	Varied amounts
Process gases	NA	NA	Varied amounts

NA - Not Applicable

(1) Based on potassium hydroxide concentration

(2) There is no regulatory threshold or screening amount for cadmium nitrate. It is included because it can release toxic oxides of cadmium under high temperatures.

(3) Several beamline experiments use small amounts of flammable gases within their neutron detectors.

in quantities that may pose substantial risks to humans or the environment.

Table S.7-2 depicts the inventory of chemicals and other nonradiological hazards that can be found at the HFBR at or near screening levels.

S.7.10.3 Industrial Hazards

Certain industrial hazards are encountered with any large industrial operation and must be considered for all alternatives. Hoisting and lifting, electric shock, noise, confined spaces, lasers, heat, and steam are industrial hazards that could be encountered. Operations at the HFBR expose workers to these industrial hazards during the normal conduct of their work activities. Occupational safety and health training that includes specialized job safety and health training appropriate to the work performed is provided for all employees at the HFBR.

S.7.11 WASTE MANAGEMENT

Table S.7-3 compares the existing storage capacities with the expected annual generation rates for each alternative. Note that BNL does not dispose of any solid wastes onsite, it only stores and packages them for transport offsite to approved treatment and disposal facilities. Therefore, the environmental impacts of each alternative are evaluated by comparing the waste generation rates of each alternative to BNL's storage capacity and ability to package and transport each waste type.

As Table S.7-3 indicates, the maximum impact on the Waste Management Facility would not exceed 30 percent of BNL's waste storage capacity (liquid low level radioactive waste [LLW]) and in most scenarios is much less. Considering that BNL only stores its wastes temporarily and that BNL has ample capacity to accommodate the expected waste generation rates for each alternative, the wastes generated by any alternative will pose no significant impact on BNL waste management.

Table S.7-3. Estimated Annual Waste Generation for the HFBR Alternatives

Category	No Action	Resume Operation 30 MW	Resume Operation 60 MW	Resume Operation & Enhance Facility	Permanent Shutdown	BNL Storage Capacity
SNF	0	77 max. ^c	158 max. ^c	158 max. ^c	0	1000 elements
Low Level Radioactive Waste						
Liquid	80 m ³	80 m ³	80 m ³	80 m ³	38 m ³ ^b	265 m ³
% Capacity	30%	30%	30%	30%	15%	
Solid	23 m ³	37 m ³	42 m ³	42 m ³ ^a	11 m ³ ^b	540 m ³
% Capacity	4.3%	6.9%	7.8%	7.8%	2.0%	
Mixed	1.3 m ³	1.7 m ³	1.7 m ³	1.7 m ³	1.0 m ³ ^b	19 m ³
% Capacity	6.8%	8.9%	8.9%	8.9%	5.2%	
Hazardous	1.8 m ³	2.4 m ³	2.4 m ³	2.4 m ³	1.0 m ³ ^b	117 m ³
% Capacity	1.5%	2.1%	2.1%	2.1%	0.9%	
Industrial	Industrial waste generation expected to remain constant under all alternatives.					NA

^a This value does not include a one-time increase of 30 m³ (1,000 ft³) due to enhancement of the facility.

^b During the first two years of this alternative the expected waste generation is: Solid LLW 60 m³ (2,000 ft³), Mixed waste 15 m³ (500 ft³), Hazardous waste 5 m³ (170 ft³), in addition a one time generation of Liquid LLW from the draining of the HFBR systems in preparation for D&D of 42.0 m³ (11,000 gal) of heavy water and 38.0 m³ (10,000 gal) light water.

^c An additional 28 elements will be generated approximately once every five years for 60 MW operation, and once every eight years for 30 MW operation.

S.7.12 ENVIRONMENTAL JUSTICE

EPA's Office of Environmental Justice offers the following definition of Environmental Justice:

The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including racial, ethnic, or socioeconomic group should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies.

The goal of this "fair treatment" is not to shift risks among populations, but to identify potential disproportionately high and adverse effects and identify alternatives that may mitigate these impacts.

The ROI contains a relatively small racial minority population. In 1990, the ROI population was 88.4 percent white compared to 74 percent for the State of New York and 80.3 percent for the Nation. African-Americans comprised 7.4 percent of the population compared to 15.9 percent for the State and 12.1 percent for the Nation. Other minority groups comprise less than 5 percent of the total population. Persons of Hispanic ethnicity accounted for 6.3 percent of the ROI residents. In addition, the ROI is relatively affluent with only 4.2 percent of the population living below the poverty level (defined in 1990 as income less than \$13,359 for a family of four).

S.8 ENVIRONMENTAL IMPACTS

S.8.1 OVERVIEW

The potential environmental impacts of the four alternatives (No Action, Resume Operation at 30 MW or 60 MW, Resume Operation and Enhance Facility, or Permanent Shutdown) analyzed in this DEIS are presented in Table S.8-1 (which begins on page S30) for comparison. Impacts are presented in the table according to affected resource areas for each alternative. By reading across the table, impacts on a resource area can be compared side-by-side for each alternative. Reading down the table, resources are presented in the same order they are presented in Section S.7, the Affected Environment.

An important consideration regarding each alternative is that none of the alternatives involve construction or modifications that would affect land areas outside the HFBR building. As a result, several resource areas would not be impacted because actions that might affect the resource would not occur. For example, impacts to land use, visual resources, geologic resources, seismicity, and cultural resources would not occur under any of the alternatives. In all of these cases, there are no significant environmental discriminators among the alternatives.

Much of the information presented in the table for operation of the HFBR is based on historic data. Data collected during years when the HFBR operated at the same power level as the level associated with the alternative is used as the basis for identification of potential impacts. For example, in the Public and Occupational Health and Safety analysis, data from operation of the HFBR in 1988 were used as the basis for determining the impacts of 60 MW operation (Resume Operation at 60 MW Alternative and Resume Operation and Enhance Facility Alternative). Data from 1997 were used for 0 MW operation (the No Action Alternative and the Permanent Shutdown Alternative), and 1995 data was used for Resume Operation at 30 MW Alternative. These years correspond to the most

representative years when the HFBR operated at the same power levels.

In June 1997, the House Committee on Appropriations authorized DOE to provide up to \$225,000 directly to the U.S. Nuclear Regulatory Commission (NRC) for identification and assessment of significant HFBR safety issues, compliance with DOE safety requirements, and potential issues related to regulation of BNL by entities other than DOE. The NRC assessment (NRC 1999) "identified no safety-significant issues, although several apparent instances of noncompliance with DOE and BNL requirements were noted." The assessment report concludes that "the safety programs at the HFBR were found to provide adequate protection of the health and safety of the public, the workers, and the environment." The NRC assessment report also concludes that "actions taken to characterize and control the groundwater tritium plume were conservative, and this tritium plume does not present a radiological hazard to public health or safety. Monitoring and control of effluents at the HFBR were acceptable. Releases were well below the applicable limits and followed ALARA [as low as reasonably achievable] practices."

S.8.2 SIGNIFICANT ISSUES IDENTIFIED FOR ANALYSIS IN THIS EIS

The information presented in Table S.8-1 (which begins on page S-30) focuses on the issues identified in Section S.3.3, Significant Issues for Analysis. In particular, radiological emissions to air and water resources, and their potential impact on human health receive the greatest attention. Thus, potential impacts from radiological discharges to water resources appear in the discussions of Water Resources, Ecological Resources, and Public and Occupational Health and Safety. The most significant issues raised by the public during the scoping process include human health and safety, water resources, socioeconomics, and waste management. Also, consistent with Congressional direction, the EIS summarizes the tritium remediation plan and program and

assesses the potential for the HFBR's further contributing to groundwater contamination.

S.8.2.1 Human Health and Safety

Section 4.11 of the DEIS describes the public and occupational health and safety for each of the proposed alternatives for the future of the HFBR. Experiences from past routine operations of the HFBR that are similar to potential future operations were used to estimate the radiological health consequences to the public and to onsite workers at BNL. HFBR operations during 1988 and 1995 are used in the analysis of operations since these years represent operations at 60 MW and 30 MW respectively. The most recent period for which a full year of operational data are available on shutdown, 1997, was used to estimate the shutdown conditions.

The relative consequences of postulated accidents for each alternative are assessed. A probabilistic risk assessment (PRA) technique that used event tree and fault tree methodologies was used to develop the accident scenarios and their potential consequences. This approach necessitated including some assumptions that simplify and overstate the frequencies and risks of some postulated accident scenarios. Overstatement of risks also occurs due to physical safety improvements that have been made to the HFBR that would reduce the likelihood of accidents occurring and would mitigate potential consequences. The accident analysis discusses postulated "design basis accidents," which are accident conditions that are accounted for in the design and operation of the HFBR. The possible occurrence of these postulated accidents has been incorporated into the design process and safety assessments. Thus, the HFBR has been built to withstand design basis accidents because they were planned for (that is, "designed out"), and their potential consequences can be mitigated. Design basis accidents are also described as "credible" accidents which means that they have a one in one million or greater chance of occurring per year. This is the same as a frequency of 10^{-6} (0.000001) per year. The accident analysis also discusses "beyond design

basis accidents," which are similar to design basis accidents, but which have complicating factors that either render the consequences greater or which have initiators that cannot be designed out. Beyond design basis accidents also have predicted frequencies of occurrence that are much less likely. These accidents often are described as "incredible" which means that their chance of occurring is less than one in one million per year, usually one in ten million (10^{-7} or 0.0000001) or less, per year. This makes beyond design basis accidents extremely unlikely to occur. These accidents are discussed further and explained in Section C.5 of Appendix C of this DEIS.

No Action: Based on the analysis in Section 4.11.1 of the DEIS, the radiological consequences to the public and to workers from normal operations associated with the No Action Alternative are expected to be extremely small, with no potential latent cancer fatalities (LCF). Under the No Action Alternative, the HFBR would continue to have no nuclear fuel and therefore could not have an accident involving fuel damage. Postulated accidents are not expected to result in any airborne emissions external to the confinement building. Consequences of non-fuel accidents would be extremely small (4.9×10^{-6} LCFs) with respect to non-involved workers and the public. The calculated doses to the non-involved workers and the public would be below the DOE regulatory annual limits for protection of health. The individual average dose would be 1.9×10^{-6} millirem per year (mrem/yr) (or 0.0000019 mrem/yr); the DOE regulatory limit is a total of 100 mrem from all pathways from a DOE facility to a member of the general public. The average dose to the involved worker would be 98 mrem per year.

Resume Operations: Based on the analysis in Section 4.11.2 of the DEIS, the radiological consequences to the public and to workers would be minimal from normal operations associated with the alternative for resuming operations at 30 MW. Operations at 30 MW would result in the estimated annual doses to the maximally exposed individual (MEI) of 3.0×10^{-4} mrem/yr (or 0.0003 mrem/yr), to the

population in the ROI of 0.035 person-rem/yr, and to the involved HFBR worker of 133 mrem (an increase of 0.00022 mrem, 0.025 person-rem, and 35 mrem respectively in comparison with the No Action Alternative). These doses are not expected to result in any health effects such as potential LCFs. The calculated doses would be below the regulatory limits for protection of human health; the DOE regulatory limit is a total of 100 mrem from all pathways from a DOE facility to a member of the general public. Several accident scenarios for the Resume Operation Alternative — 30 MW have been postulated and assessed.

For the postulated credible design basis accidents, the consequences are predicted to be extremely small, such that no health effects or potential LCFs would be expected. The incredible or beyond design basis accident with the most potential for offsite consequences is postulated to occur from a severe wind/tornado event. The expected frequency for such a rare event would be less than 10^{-6} per year (or a one in one million chance per year), while the consequences are calculated to be a dose of 61 rem to the MEI and 81 potential LCFs to the public. These potential consequences are moderated by the fact that the PRA used a very conservative analysis that overestimated the probabilities of human error as a part of the accident scenario. The probability of this postulated accident actually occurring is considered to be extremely unlikely and the predicted consequences are considered to be an overestimation. A probability of a postulated large loss of coolant accident with major core damage during 30 MW operations is estimated to be extremely remote (less than 10^{-7} per year, or less than a one in ten million chance per year) with only minor consequences.

Based on the analysis in Section 4.11.3 of the DEIS, the radiological consequences to the public and to workers would be minimal from normal operations associated with the alternative for resuming operations at 60 MW. Operations at 60 MW would result in the estimated annual doses to the MEI of 5.6×10^{-4} mrem/yr (or 0.00056 mrem/yr), to the population in the ROI of 0.069 person-rem/yr, and to the involved

HFBR worker of 203 mrem (an increase of 0.00048 mrem, 0.059 person-rem, and 105 mrem respectively in comparison with the No Action Alternative). These doses are not expected to result in any health effects such as potential LCFs. The calculated doses would be below the regulatory limits for protection of human health. Several accident scenarios for the Resume Operation Alternative — 60 MW have been postulated and assessed.

For the postulated credible design basis accidents, the consequences are predicted to be extremely small, such that no health effects or potential LCFs would be expected. The incredible or beyond design basis accident with the most potential for offsite consequences is postulated to occur from a severe wind/tornado event. The expected frequency for such a rare event would be less than 10^{-6} per year (or a one in one million chance per year), while the consequences are calculated to be a dose of 110 rem to the MEI and 115 potential LCFs to the public. As is the case with the PRA assessment at 30 MW, these potential consequences are moderated by the fact that the PRA used a very conservative analysis that overestimated the probabilities of human error as a part of the accident scenario. The probability of this postulated accident actually occurring is considered to be extremely unlikely, while the predicted consequences are considered to be an overestimation. A probability of a postulated large loss of coolant accident with major core damage during 60 MW operations also is estimated to be extremely remote (less than 10^{-7} per year, or a one in ten million chance per year).

Resume Operation and Enhance Facility:

Based on the analysis in Section 4.11.4 of the DEIS, the radiological consequences to the public and to workers would be the same as for the Resume Operation Alternative — 60 MW discussed above. Consequences are expected to be minimal.

Permanent Shutdown: Under the Permanent Shutdown Alternative, the scientific mission of the HFBR would be terminated. The facility would be prepared for placement into an

industrially and radiologically safe condition for an extended period of time that would involve surveillance and maintenance. The placement of the facility into an industrially and radiologically safe condition would entail some radiological doses to workers, primarily due to efforts necessary to remove the radioactive systems and subsystems, and their associated components. The worker doses would not be expected to be any greater than for workers during a defueling phase or during normal maintenance when the facility was operational. The doses to the offsite population would also be of a similar level.

S.8.2.2 Water Resources and Tritium

Section 4.5 of the DEIS assesses the impacts to water resources of the BNL region from the four alternatives for the future of the HFBR. Section 1.8 of the DEIS discusses the remediation of tritium contamination. The main concerns expressed by the public with respect to water resources are related to the public health aspects and environmental quality of discharges, emissions, and leaks of tritium to the groundwater aquifer and to the Peconic River. Similarly, Congress also expressed the need to provide detailed planning for the remediation of the groundwater contaminated with tritium from the HFBR.

Tritium Sources and Their Reduction and Management: The production of tritium, a naturally occurring isotope of hydrogen, would be a byproduct of the operation of the HFBR. Except for the leaking spent fuel pool at the HFBR, the release of minor amounts of tritium to the environment has been an unavoidable consequence of operating the HFBR. Under the Resume Operation Alternatives for the future of the HFBR, tritium would be released in air emissions from the HFBR stack and in small amounts from the HFBR cooling towers. Trace amounts of tritium would be in the water discharged from the HFBR cooling towers into an onsite recharge basin. Under all of the alternatives, small amounts of tritium would be present in liquid effluents piped from the HFBR to the STP and subsequently discharged into the Peconic River, in full compliance with BNL's SPDES permit. Extraction well pumping of the

leading edge of the groundwater plume contaminated with tritium also would be discharged into an onsite recharge basin. None of these emissions or discharges would be expected to have any adverse impact on environmental quality, nor would any create adverse health effects to workers or the public.

DOE understands that value differences, whether real or perceived, with respect to environmental quality, drive the acceptability in local communities of the Department's scientific research on behalf of the Nation. These apparent value differences also are the major underlying cause of controversy with respect to environmental quality, as is the case with the tritium contamination of the aquifer and the potential for tritium contamination of other environmental resources at BNL. However, the uncontrolled tritium release has created a public belief that DOE and BNL hold different sets of values with respect to the environment than DOE and BNL share with the local Long Island community. DOE intends to follow the plans set out in this DEIS for both tritium remediation of past problems and for the minimization and prevention of future tritium pollution from the HFBR under any of the alternatives that would be chosen as the future of the HFBR. By so doing, DOE will work to improve its stewardship of the environment and to demonstrate that it values the local environment and the local community during the course of conducting research for the Nation.

DOE intends to reduce as much as possible the releases and emissions of tritium under any of the alternatives for the future of the HFBR to avoid further impact to the environment and to reduce the level of controversy in the local community. Under whichever alternative is chosen, DOE will, to the furthest extent practical, "begin as clean as possible" under that alternative and "stay as clean as possible" with respect to tritium releases (controlled or uncontrolled) to the environment. Section 2.3 of this DEIS describes several modifications and repairs within the HFBR that will reduce significantly the potential for preventable leakage of contaminated water to the aquifer. These modifications and repairs include

installing a double-walled, stainless steel liner in the spent fuel pool to eliminate the past leak and to ensure that it does not leak in the future. Also, planned repairs include floor joints, piping systems and sumps, and to drains that will isolate any accidental spills within the HFBR and prevent them from reaching the outside environment.

Additionally, the possibility of minor leakage in the HFBR sanitary sewer lines will be examined and tested. A test conducted late in 1997 measured a sewer line system loss rate of approximately 15 liters per day (1pd) to 26 1pd (4 gallons per day [GPD] to 7 GPD), indicating that the below-grade sanitary piping is in reasonably good condition and confirming that it could not be a major contributor to the existing tritium contamination. While the leak rate from the sanitary system sewer line appears comparable to the former leak from the spent fuel pool (23 1pd to 34 1pd [6 GPD to 9 GPD]), the average annual tritium concentrations are extremely different. In 1996, the average annual tritium concentration at the discharge from the HFBR sanitary system was about 7,100 picocuries/l (pCi/l). This concentration is about one-third of the Safe Drinking Water Act (SDWA) standard of 20,000 pCi/l that is established by the EPA for protection of human health. The average spent fuel pool tritium concentration was about 40,000,000 pCi/l, with a noted increase to 140,000,000 pCi/l in 1995. Following further inspections and repairs, additional leak testing of the sanitary system is planned to ensure that the sanitary system integrity satisfies Suffolk County Department of Health Services building and sanitary code requirements.

Waste minimization and pollution prevention plans and practices are implemented by BNL to reduce waste generation from all BNL research activities. These practices are incorporated into all BNL operations at the earliest feasible stage of project planning and research design. Regardless of the alternative ultimately selected for the future of the HFBR, waste minimization and pollution prevention principles and practices will be applied to the management of tritium

generation and release from all potential sources at the HFBR. HFBR personnel will track tritium waste generation and routinely evaluate activities to identify measures that could be implemented to reduce both the waste to be generated and the waste potentially to be released. These practices and principles will be applied in order to continue the trend in tritium waste reduction realized over the last several years. To reduce the tritium levels in the sanitary waste system, the discharge from the air conditioners (on the HFBR Equipment Level) to the sanitary system, and ultimately to the STP, was stopped in 1995. The Operations Level condensate discharge was stopped in 1996. These process changes constituted a significant and permanent reduction in sanitary system tritium discharges. During the last 15 years, the amount of tritium discharged to the Peconic River has decreased by more than 83 percent. Continued attention to further reduction of tritium discharges to the environment will be a part of the overall waste minimization and pollution prevention practices and the operational philosophy at the HFBR under any of the alternatives for the future of the facility. Progress in reducing tritium generation, discharges, and emissions from the HFBR under any of the alternatives will continue to be reported to the public in BNL's annual *Site Environmental Report*.

As noted above, the NRC assessment report also concludes that "actions taken to characterize and control the groundwater tritium plume were conservative, and this tritium plume does not present a radiological hazard to public health or safety. Monitoring and control of effluents at the HFBR were acceptable. Releases were well below the applicable limits and followed ALARA [as low as reasonably achievable] practices."

Remediation of Tritium Contaminated Groundwater: In response to the leak of tritiated water from the HFBR spent fuel pool to the groundwater aquifer, DOE established a formal Tritium Remediation Project (TRP) at BNL in the spring of 1997. The purpose of the TRP is to implement an interim and accelerated response to ensure protection of public health

and the environment. Several initiatives are incorporated within the interim response of the TRP, including placement of sampling wells, tritium sampling and monitoring of groundwater, extraction pumping of the leading edge of the contaminated groundwater plume, engineering evaluations, and the modeling of groundwater movements and migration. The TRP is discussed in more detail in Section 1.8 of this DEIS.

The combined sampling, monitoring, and modeling efforts conducted since 1997 have defined the dimensions of the tritium plume within the groundwater aquifer, as well as its geographic location within the BNL site boundaries. The dimensions and location of the plume are defined by the concentration of tritium in the groundwater, in comparison with the SDWA standard of 20,000 pCi/l that is established by the EPA for protection of human health. That portion of the aquifer contaminated in excess of this SDWA standard extends approximately 800 m (2,600 ft) south of the HFBR, which is a point about 1,500 m (4,800 ft) north of the southern boundary of BNL. This plume occurs at a depth of 12 m to 15 m (40 ft to 150 ft) below the land surface and its maximum width is about 76 m (250 ft) wide. Tritium concentrations at the leading edge of the plume are less than 1,000 pCi/l. The concentration of tritium in the groundwater decreases to about 6,440 pCi/l at a location 1,100 m (3,600 ft) south of the HFBR, and to 1,000 pCi/l at 1,300 m (4,300 ft) south. The 1,000 pCi/l edge is approximately 800 m (2,600 ft, or about one-half mile) from the southern BNL boundary. The tritium contaminated groundwater, therefore, is located entirely within the borders of BNL and is not contaminating any local water used for drinking. The groundwater studies have determined that the groundwater in the aquifer beneath BNL moves at an average velocity of 0.25 m per day (or about 0.8 ft per day). At that rate of movement it would take approximately 16 years for the 20,000 pCi/l edge of the plume to reach the southern BNL boundary. In that period of time, the natural decay of tritium would reduce the concentration to less than half of this contamination level. The

health of the public is not at risk from this contaminated groundwater.

As added insurance against the plume ever reaching or crossing the BNL boundary, BNL began operating an interim pump-and-recharge system in May 1997 in order to intercept the tritium contaminated groundwater plume. In the future, depending on plume concentrations, pumps may be placed in standby or may continue in service. This interim measure also provides time for DOE and BNL to study alternative remediation methods and technologies in order to prepare a long-term plan to permanently clean up the most contaminated portions of the groundwater plume. The interim pump-and-recharge initiative operates using three extraction wells located approximately 1,100 m (3,600 ft) south of the HFBR near Princeton Avenue, where the maximum concentration of tritium in the groundwater is about 6,440 pCi/l. The groundwater is pumped from a depth of about 45 m (150 ft) and piped northward to an existing onsite recharge basin where it is discharged under a NYSDEC permit. The maximum concentration of tritiated groundwater entering the recharge basin has been 1,800 pCi/l, with most of the water below the detection limits of 400 pCi/l. Concern was raised that evaporation of tritium contaminated water from the recharge basin might pose a health risk to people, and that wildlife might be at risk from drinking the water in the basin. Tritium concentrations in the air around the recharge basin are being monitored continuously. The levels have been below the limits of detection and do not pose any risk to human health of onsite workers or the public. The very low levels of tritium in the water in the recharge basin do not pose any risk to wildlife. Monitoring will continue.

No Action: Under the No Action Alternative, the HFBR would continue in its defueled and shutdown mode and the spent fuel pool would be refilled and used for the temporary storage of radioactive components such as control rod blades. The pool would have been modified and lined to meet Suffolk County Sanitary Codes such that it would not be expected to leak into the groundwater aquifer. Sanitary waste would

continue to be generated and transferred to the STP for processing and release to the Peconic River. The continued attention to both controlled and potential uncontrolled releases of contaminated liquids to groundwater resources will minimize impacts. Waste minimization and pollution prevention practices will be implemented as well. Based on the analysis in Section 4.5.1 of the DEIS, the radiological consequences to the environment and to human health associated with the No Action Alternative are expected to be extremely small.

Resume Operations: Under the Resume Operation Alternative – 30 MW, the HFBR would be refueled and the spent fuel pool would be refilled and used. The pool would have been modified and lined to meet Suffolk County Sanitary Codes such that it would not be expected to leak into the groundwater aquifer. Tritium would continue to be generated as an unavoidable consequence of operations. Based on past operational experience, the discharge of water to the STP is expected to have a tritium concentration of about 3,000 pCi/l, which is well below the SDWA standard. Waste minimization and pollution prevention practices would be followed in order to generate and release minimal tritium to the environment. All of the repairs and modifications to the HFBR would reduce substantially the probability of spills or leaks reaching the environment, and thus minimize any risk to public health. Additionally, in order to keep tritium concentrations and releases as low as possible, the heavy water reactor coolant would be replaced periodically. This would be an operational practice that would be part of both the waste minimization and pollution prevention initiatives. Based on the analysis in Section 4.5.2 of the DEIS, the radiological consequences to the environment and to human health associated with this operational alternative are expected to remain extremely small.

Under the Resume Operation Alternative – 60 MW, the HFBR would be refueled and the spent fuel pool would be refilled and used. The pool would have been modified and lined to meet Suffolk County Sanitary Codes such that it would not be expected to leak into the

groundwater aquifer. Tritium would continue to be generated as an unavoidable consequence of operations. The operations, discharges and emissions during operations at 60 MW would be slightly increased with respect to operations at 30 MW. Waste minimization and pollution prevention practices would be followed in order to generate and release minimal tritium to the environment. All of the repairs and modifications to the HFBR would reduce substantially the probability of spills or leaks reaching the environment, and thus minimize the risk to public health. Additionally, in order to keep tritium concentrations and releases as low as possible, the heavy water reactor coolant would be replaced periodically and more frequently at this higher operating power level. This would be an operational practice that would be part of both the waste minimization and pollution prevention initiatives. Based on the analysis in Section 4.5.3 of the DEIS, the radiological consequences to the environment and to human health associated with this operational alternative are expected to remain extremely small.

Resume Operations and Enhance Facility: Under the Resume Operation and Enhance Facility Alternative, the HFBR would be refueled, the spent fuel pool would be refilled and used, and the facility would be operated at up to 60 MW. The pool would have been modified and lined to meet Suffolk County Sanitary Codes such that it would not be expected to leak into the groundwater aquifer. Tritium would continue to be generated as an unavoidable consequence of operations. Operations and potential impacts would be similar to those for the Resume Operations Alternative at 30 MW and 60 MW.

Permanent Shutdown: Under the Permanent Shutdown Alternative, the scientific mission of the HFBR would be terminated. The facility would be prepared for placement into an industrially and radiologically safe condition for an extended period of time that would involve storage and maintenance. The primary cooling system would be emptied of its contents. The spent fuel pool would be refilled and used during storage and maintenance activities, and

during D&D activities. The pool would have been modified and lined to meet Suffolk County Sanitary Codes such that it would not be expected to leak into the groundwater aquifer. There would be no other tritiated fluids remaining in the HFBR during the remainder of the storage and maintenance or D&D periods. The potential impacts to the environment associated with this alternative, therefore, are expected to be inconsequential and less than the No Action Alternative.

S.8.2.3 Socioeconomics

Section 4.9 of the DEIS describes the projected socioeconomic consequences for each of the proposed alternatives for the future of the HFBR. In terms of this DEIS, socioeconomics comprise the social, economic and demographic characteristics of the Long Island communities potentially affected by the decisions concerning the future of the HFBR. These communities include the Counties of Nassau and Suffolk as the ROI. Section 3.9 of this DEIS explains the background and environmental setting for the socioeconomics analysis in this region, while Section 3.9.3 of the DEIS summarizes the influence of BNL on the regional economy.

No Action: Under the No Action Alternative, the HFBR would continue in its defueled and shutdown mode. There would be no scientific research conducted, therefore, there would be no visiting scientists, professors or students using the facility. In terms of onsite workers to manage the facility, there has been little or no effect thus far to the HFBR's permanent workforce. This workforce is expected to remain stable through the year 2000. Upon completion of the repairs and modifications (for conformance with Suffolk County Sanitary Code, Articles 7 and 12), there would likely be a reduction of the current workforce from 120 to approximately 69 employees. An additional 168 indirect jobs in the region exist as the result of the work at the HFBR. This net reduction of approximately 51 onsite employees is a high proportion of the HFBR work staff (approximately 43 percent), but a relatively small proportion (less than 2 percent) of the 3,100 person permanent BNL workforce. The

absence of visiting scientists is substantial for the HFBR, and is a relatively modest portion (approximately 12.5 percent) of the approximately 3,200 temporary workers per year (primarily visiting scientists) at BNL. These reductions in the workforce represent a modest decrease to BNL and a minor impact to the ROI. There should be no significant impact to housing or community services as a result.

Resume Operations: Under the Resume Operation Alternative — 30 MW, the HFBR would be returned to the neutron scientific research mission that was conducted prior to the 1996 shutdown. This alternative would require 130 employees, an increase of 61 compared with the No Action Alternative. There also would be an estimated 316 indirect regional jobs in support of the operations at the HFBR (an increase of about 148 jobs compared with No Action). In addition to the permanent HFBR workforce, there would be up to 400 visiting scientists using the facility per year (staying for an average of seven to ten days each). While there would be some recovered and increased economic impact to the region in the form of increased local expenditures, it is not expected to be significant in terms of the overall local economy or affecting housing or community services.

Under the Resume Operation Alternative — 60 MW, the socioeconomic impacts would be expected to be similar to those of the Resume Operation Alternative — 30 MW. Operation at 60 MW would require the same number of onsite workers to run the facility for the estimated 400 visiting scientists per year.

Resume Operation and Enhance Facility: Under the Resume Operation and Enhance Facility Alternative, the socioeconomic impacts in the near term would be expected to be similar to those of the Resume Operation Alternative — 60 MW. Operation at 60 MW would require the same number of onsite workers to run the facility for the estimated 400 visiting scientists per year. The current configuration of the HFBR is expected to perform safely for at least another decade or longer. Facility enhancements would require that the HFBR be shutdown for

one to two years during construction, while the facility components are being replaced and enhanced. There would be some new temporary construction jobs during this period. Enhancing the HFBR with a new reactor vessel and instrumentation would permit operations for another 30 to 40 years at 60 MW. This would extend the life of the facility in terms of the jobs it would support and would have a minor economic impact to the ROI.

Permanent Shutdown: Under this alternative, the HFBR would be permanently shutdown for eventual D&D. There would still be a small workforce associated with the HFBR to prepare the reactor for eventual D&D. There would be approximately 93 employees temporarily associated with this alternative, which is an increase of 24 employees compared to the No Action Alternative. A total of 82 additional jobs (24 direct and 58 indirect) would be generated as a result of this alternative. In the long run, once decisions about the D&D needs of the HFBR have been made, the workforce would eventually become zero. This would terminate permanently the 151 jobs associated with this alternative, as well as the 69 direct and 168 indirect jobs (a total of 237 jobs) associated with the No Action Alternative, and the 130 direct plus 316 indirect jobs (a total of 446 jobs) associated with the operational alternatives. This would have a slight adverse impact on the ROI economy.

S.8.2.4 Waste Management

Section 4.12 of the DEIS analyzes the environmental potential consequences of each of the four alternatives for the future of the HFBR. Experiences from past operations and current activities at the HFBR that are expected to be similar to potential future conditions are used to estimate the waste management needs and schemes for the future. Annual waste generation rates for the No Action Alternative and the Permanent Shutdown alternatives were estimated based on the five-year average of waste generated by the HFBR between 1993 and 1997. These rates then were reduced to account

for expected decreases due to lack of fuel handling (the HFBR would contain no fuel), research experiments, and reduced maintenance. BNL does not dispose of any solid wastes onsite, it only stores and packages wastes for transport to approved offsite treatment and disposal facilities. It is estimated that the maximum impact of wastes generated by the HFBR on the BNL Waste Management Facility would not exceed 30 percent of BNL's waste storage capacity for liquid LLW. Under any of the four alternatives for the future of the HFBR, the waste handling, storage, processing, and offsite shipment activities would be similar to those of previous years, as per standard BNL procedures and requirements. These activities would not be expected to create any adverse impacts to the environment or to the health of workers or the public.

Waste minimization and pollution prevention plans and practices are implemented by BNL to reduce waste generation from all BNL research activities. These practices are incorporated into all BNL operations at the earliest feasible stage of project planning and research design. These practices would be applied to all activities at the HFBR under all of the alternatives. Current and past practices at the HFBR have included the tracking of waste generation and the routine evaluation of activities at the HFBR to identify measures that can be implemented to reduce waste generation. Regardless of the alternative ultimately selected for the future of the HFBR, waste minimization and pollution prevention principles and practices will continue to be applied to all the potential sources of wastes at the HFBR, including all potential sources of tritium as discussed above in this summary. While the estimated waste generation rates for the four alternatives are based on past experience, future activities or operations would be expected to lower waste generation rates, volumes, and types compared with the past. Sections 3.12.1 and 3.12.2 of the DEIS describe BNL waste management initiatives and processes and the expectations for waste minimization and pollution prevention that would be applied to the HFBR in the future under all of the alternatives.

No Action: Under the No Action Alternative, the HFBR would remain in its present defueled and shutdown mode. No spent nuclear fuel would be generated. Sanitary waste would continue to be generated and transferred to the STP for processing and release to the Peconic River. Solid LLW would continue to be generated by routine maintenance and monitoring of the facility. Once all of the Suffolk County Sanitary Code, Articles 7 and 12 repairs and modifications are completed, the waste generation rate is expected to decrease by about 38 percent, from 37 m³ (1,300 ft³) to about 23m³ (800 ft³) per year. Reduced maintenance and operations as a result of no ongoing research activities would result in the generation of about one half the normal operational volume of compactable waste, or about 11 m³ (400 ft³). Liquid LLW would continue to be generated at about the same rate it is being generated in the current shutdown mode. Similarly, the reduced operations are expected to result in a 25 percent reduction in the rate of both mixed and hazardous waste generation, or about 1.3 m³ (45 ft³) and 1.8 m³ (65 ft³) annually.

Resume Operations: Under the Resume Operations Alternative — 30 MW, the HFBR would be refueled and operated at 30 MW. It is estimated that 63 spent fuel elements normally would be generated per year, with a maximum of 77 elements being possible. Solid and liquid LLW would be generated at the historic average of about 37 m³ (1,300 ft³) and 80 m³ (21,000 gal) respectively. Mixed waste and hazardous waste also would be generated at about the historic rates of 1.7 m³ (60 ft³) and 2.4 m³ (85 ft³) respectively. These volumes are increased compared with the No Action Alternative.

Under the Resume Operations Alternative — 60 MW, the generation of some wastes at the HFBR would be increased compared with operations at 30 MW. It is estimated that a maximum of up to 158 spent fuel elements could be generated per year, however the actual number is expected to be less. Solid LLW would be generated at a rate higher than at 30 MW, or at about 42 m³ (1,475 ft³) per year. Liquid LLW would be generated at the historic

rate of about 80 m³ (21,000 gal) per year. It is anticipated that mixed and hazardous wastes would continue to be generated at the same rates as for 30 MW operations.

Resume Operations and Enhance Facility: Under the Resume Operations and Enhance Facility Alternative, the HFBR would be upgraded, refueled, and operated at up to 60 MW. The upgrading activities would create a one-time volume of about 15 m³ (500 ft³) of non-compactable solid metal LLW, plus about 15 m³ (500 ft³) of compactable solid waste. With these exceptions, all waste generation rates would be the same as those estimated for resuming operations at 60 MW. No adverse impacts are expected.

Permanent Shutdown: Under the Permanent Shutdown Alternative, the scientific mission of the HFBR would be terminated. The facility would be prepared for placement into an industrially and radiologically safe condition for an extended period of time that would involve storage and maintenance. Under this alternative, the waste generation rates are expected to increase during the first two years as the facility is characterized and stabilized for storage and maintenance, and prepared for final D&D. The amount of solid LLW generated during that time could be two to three times that of the No Action Alternative, or about 57 m³ (2,000 ft³) per year. After the initial storage and maintenance activities are complete, reduced monitoring and maintenance activities are expected to result in roughly one half of the waste generated compared with No Action, or about 11 m³ (400 ft³) per year until D&D activities commence. Similarly, liquid LLW volumes would be increased for one to two years and then decrease to about 38 m³ (10,000 ft³) per year. The generation of mixed and hazardous wastes would increase during the first one to two years to about 15 m³ (500 ft³) and 5.7 m³ (200 ft³) respectively, and then decrease to about 1 m³ (35 ft³) each per year. No adverse impacts are expected.

S.8.3 COMPARISON OF ALTERNATIVES

Following is a summary table comparing the environmental impacts of the four alternatives considered in this DEIS. The reader is reminded that greater detail concerning the analysis can be found in the full text of Chapter 4 and related Appendices of the DEIS.

Table S.8-1. Comparison of Alternatives

Resource	Alternative:				
	No Action	30 MW	60 MW	Enhanced	Shutdown
Land Use/Visual	The exterior of the HFBR would not be modified. There would be no impact on current land use or visual resources.			Enhancement of the HFBR would not involve construction affecting the exterior of the facility. There would be no impact on current land use or visual resources.	Shutdown and long-term maintenance and surveillance would not affect the exterior of the HFBR. Eventual D&D may affect HFBR's exterior (visual resource) depending on the D&D approach selected (e.g., demolition), but land use would not be changed. Prior to D&D, there would be no impact on land use or visual resources.
Infrastructure	Electric power and steam use for HFBR equals 2% each of the BNL requirement (4,000 MWh/yr and 4.5×10^6 kg/yr, respectively). Water use for the HFBR equals 1% (0.2 MLD) of BNL usage. These small percentages of site requirements do not represent a significant impact.	Electricity use would increase to 14,000 MWh/yr, a 5% increase in BNL consumption. Steam use would increase to 1.1×10^7 , a 2% increase over No Action. Water use for the HFBR would increase to 1.4 MLD, a 9% increase of BNL usage over No Action. These use rates are well within historic rates and site capacities. Therefore, these increases do not represent significant impacts.	Electricity use would increase to 14,000 MWh/yr, a 5% increase in BNL consumption. Steam use would increase to 1.5×10^7 , a 4% increase over No Action. Water use for the HFBR would increase to 2.8 MLD, an 18% increase of BNL usage over No Action. These use rates are well within historic rates and site capacities. Therefore, these increases do not represent significant impacts.	Electricity, steam, and water use rates during enhancement activities would not exceed use rates during operation. Operation rates would be the same increases as operation at 60 MW. These rates are well within historic usage and site capacities. Therefore, these rates do not represent significant impacts.	Long-term surveillance and maintenance activities require nearly identical electricity, steam, and water usage as current shutdown, which is also the case in No Action. Therefore, no significant impacts would be expected.

Table S.8-1. Comparison of Alternatives — Continued.

Resource	Alternative:				
	No Action	30 MW	60 MW	Enhanced	Shutdown
Air Quality — Radiological	Radiological air quality is assessed for impacts to human health: see Public and Occupational Health and Safety.				
Air Quality — Non-Radiological	Air emissions associated with restoration construction equipment, building heating, ventilation, and air conditioning (HVAC), and vehicle exhaust from routine deliveries would have a very small impact.	HVAC, vehicle exhaust from routine deliveries, and laboratory equipment emissions would have a very small impact.	Non-radiological air emissions would not increase as a result of increasing operational power from 30 to 60 MW. Therefore, HVAC, vehicle exhaust from routine deliveries, and laboratory equipment emissions would have a very small impact.	HVAC, vehicle exhaust from routine deliveries, and laboratory equipment emissions would have a very small impact.	HVAC, vehicle exhaust from routine deliveries, and laboratory equipment emissions would decrease after shutdown activities are complete.
Noise	Drilling of characterization wells for environmental restoration activities would be the major source of noise in the vicinity of the HFBR. Noise from drilling would not be audible at BNL site boundary. Continued shutdown of cooling tower operations would keep noise at reduced levels.	The primary source of noise would be from cooling tower operations. This noise would not be audible offsite, and impacts would be minor.	The primary source of noise would be from cooling tower operations. Noise levels would be similar to 30 MW operation, and impacts would be minor.	The primary source of noise would be from cooling tower operations. Noise levels would be similar to 30 MW operation, and impacts would be minor. Noise associated with enhancement activities would be primarily internal to the HFBR structure, and would have a minor impact on outdoor noise levels.	No noise from cooling tower operations would occur under shutdown or long-term surveillance and maintenance.

Table S.8-1. Comparison of Alternatives — Continued.

Resource	Alternative:				
	No Action	30 MW	60 MW	Enhanced	Shutdown
Water Resources <hr/> Surface Water	Discharge from the HFBR to the Peconic River via the Sewage Treatment Plant (STP) is about 0.15 MLD. Tritium concentration in STP discharges is about 1,350 pCi/l, well below the drinking water standard of 20,000 pCi/l. This low concentration of tritium is not a significant impact on surface water quality.	Discharge to STP would increase to about 0.27 MLD. Potential increase in tritium concentration in discharges to Peconic River via STP could be up to about 2,700 pCi/l. This would not represent a significant impact to Peconic River water quality.	Discharge to STP would increase to about 0.33 MLD. The concentration of tritium from the STP would be the same as under the 30 MW Alternative (about 2,700 pCi/l equals 14% of the drinking water standard). This would not represent a significant impact on Peconic River water quality.	Enhanced facility operation would discharge a level of tritium similar to 60 MW Alternative. This level would not represent a significant impact on Peconic River water quality.	Prior to D&D, discharge to STP would be the same as No Action. Following D&D there would be no discharges to the STP. No significant impacts would be expected.
Water Resources <hr/> Groundwater	Modifications to the HFBR facility to comply with Suffolk County Sanitary Code, Articles 7 and 12 eliminated a major source of tritium contamination. The small amount of tritium that could leak from sanitary sewer lines connecting HFBR to the STP is not expected to have a significant impact on groundwater quality.	Low levels of tritium could leak from HFBR sewer lines, secondary cooling water system, and Recharge Basin HO. There are no in-service onsite supply wells located down gradient from the HFBR. The concentrations of tritium that could leak from the sewer lines or infiltrate from Recharge Basin HO would likely be very low, well below the drinking water standard of 20,000 pCi/l. No significant impact to groundwater quality would be expected.	Low levels of tritium could leak from HFBR sewer lines, secondary cooling water system, and Recharge Basin HO. Levels of tritium would be expected to be similar to 30 MW Alternative, and would not be expected to have a significant impact on groundwater quality.	Impacts to groundwater quality would be from the same sources and at the same levels as the 60 MW Alternative. Impact to groundwater would not be expected to be significant.	Removal of radioactive fluids would eliminate potential for leakage. Without the potential for leaks, there would be no impact on groundwater quality.

Table S.8-1. Comparison of Alternatives — Continued.

Resource	Alternative:				
	No Action	30 MW	60 MW	Enhanced	Shutdown
Geology	No new construction or ground-disturbing activities are planned that would impact soil or geologic resources.				Shutdown would not involve construction or ground-disturbing activities. No impact to soil or geologic resources would occur.
Seismicity	Maximum recorded acceleration in the area was 0.015 g. No active faults are known in the Long Island area. The reactor building is capable of withstanding horizontal accelerations of 0.2 g., and no consequences from seismic activity are expected following completion of the seismic upgrades to the control room and operations level crane.				
Ecological Resources — Terrestrial Resources	No new construction or ground-disturbing activities would occur that could impact terrestrial resources.	No new construction or ground-disturbing activities would occur. Vegetation sampling from area surrounding BNL detected no radionuclides attributable to HFBR 30 MW operation air emissions. Therefore, no appreciable impacts to terrestrial resources would be expected.	No new construction or ground-disturbing activities would occur. Vegetation sampling from area surrounding BNL detected no radionuclides attributable to HFBR 30 MW operation air emissions. 60 MW operations would be expected to yield similar results. Therefore, no appreciable impacts to terrestrial resources would be expected.	No new construction or ground-disturbing activities would occur. Impacts to aquatic resources would be the same as for the 60 MW alternative.	No new construction or ground-disturbing activities would occur that could impact terrestrial resources.

Table S.8-1. Comparison of Alternatives — Continued.

Resource	Alternative:				
	No Action	30 MW	60 MW	Enhanced	Shutdown
Ecological Resources — Wetland Resources	No new construction or ground-disturbing activities would occur that could impact wetland resources. Air emissions would not be expected to appreciably impact wetland resources.				
Ecological Resources — Aquatic Resources	HFBR wastewater discharges to the Peconic River via the STP contain low levels of tritium. Exposure doses from STP discharges would not exceed 1 rad/day, a DOE guideline expected to be protective of aquatic biota. Therefore, no appreciable impacts to aquatic resources would be expected.	No new construction would affect aquatic resources. Exposure doses from tritium levels in HFBR wastewater discharges via the STP and into Recharge Basin HO would not exceed 1 rad/day, a DOE guideline expected to be protective of aquatic biota. Therefore no appreciable impacts to aquatic resources would be expected.	No new construction would affect aquatic resources. At 60 MW operation, exposure doses from tritium levels in HFBR wastewater discharges via the STP and into Recharge Basin HO would not exceed 1 rad/day, a DOE guideline expected to be protective of aquatic biota. Therefore no appreciable impacts to aquatic resources would be expected.	No new construction would affect aquatic resources. Impacts to aquatic resources would be the same as the 60 MW alternative.	Discharges to the Peconic River via the STP would eventually cease. Therefore any existing potential impacts would cease.

Table S.8-1. Comparison of Alternatives — Continued.

Resource	Alternative:				
	No Action	30 MW	60 MW	Enhanced	Shutdown
Ecological Resource Threatened and Endangered Species Habitats	No new land disturbing activities would impact Federal or State-listed endangered, threatened, or special concern species. Discharges to the Peconic River would not impact threatened, endangered, or special concern species as none are known to occur in the vicinity of the STP.	No new land disturbing activities would impact Federal or State-listed endangered, threatened, or special concern species. Discharges to the Peconic River and Recharge Basin HO would not impact threatened, endangered, or special concern species as none are known to occur in HO or in the vicinity of the STP.	No new land disturbing activities would impact Federal or State-listed endangered, threatened, or special concern species. Discharges to the Peconic River and Recharge Basin HO would increase over 30 MW operation, but would not impact threatened, endangered, or special concern species as none are known to occur in HO or in the vicinity of the STP.		No new land disturbing activities would impact Federal or State-listed endangered, threatened, or special concern species. Discharges to the Peconic River would cease. Therefore, no impacts to threatened, endangered, or special concern species would occur.
Cultural Resources	There would be no impact because no actions would disturb land or structures, and there are no known cultural resources or traditional cultural properties in the vicinity of the HFBR.				
Socioeconomics	A total of 237 jobs (69 direct, 168 indirect) would continue, resulting in earnings of \$21.5 million within the ROI. This is equal to 0.02% of both jobs and earnings within the ROI.	A total of 446 jobs (130 direct, 316 indirect) would be created, resulting in earnings of \$37.9 million within the ROI. This is equal to 0.04% of both jobs and earnings within the ROI. As many as 400 visiting scientists may also use the reactor annually. This may increase expenditures within the ROI. Jobs would likely be filled by existing workforce. No impact on regional housing market or public services would occur.			A total of 319 jobs (93 direct, 226 indirect) would be temporarily created, resulting in earnings of \$26.4 million within the ROI. This is equal to 0.03% of both jobs and earnings within the ROI.
Jobs would likely be filled by existing workforce. No impact on regional housing market or public services would occur.					

Table S.8-1. Comparison of Alternatives — Continued.

Resource	Alternative:				
	No Action	30 MW	60 MW	Enhanced	Shutdown
Transportation — Traffic	Traffic conditions would remain as they currently exist. No increase or decrease in impacts would occur.	Traffic from 130 employees and up to 400 visiting scientists would occur. Scientists would be expected to remain onsite. Employee and visitor traffic would be expected to have no appreciable impact on traffic.	Traffic related to employees (130) and visiting scientists (400) would not increase over 30 MW operations. Therefore, no appreciable impact on traffic would be expected.	Employee and visiting scientist traffic would be the same as 30 and 60 MW operation. Enhancement activities would add fewer than 100 vehicles per day. Because this represents less than 0.5% of the local traffic on William Floyd Parkway, no appreciable impacts would be expected.	Following permanent shutdown, it is anticipated that HFBR employees would be reassigned to other BNL research activities and facility maintenance. Therefore, no appreciable decrease in site traffic would occur.
Transportation — Transport of Fuel Elements	All fuel elements were transported offsite in 1997. Therefore, there would be no impact.	At 30 MW, a shipping campaign would be expected approximately once every five years. Periodically, reactor vessel components and internal parts would be replaced and shipped offsite. Analysis in the SNF PEIS supports the conclusion that no major impacts would occur from offsite shipment of this volume of spent nuclear fuel.	At 60 MW, a shipping campaign would be expected approximately once every three years. Impacts would be similar to operation at 30 MW.	Enhancement of the HFBR would not result in more nuclear fuel consumption than 60 MW operation. Transportation impacts would be similar to 60 MW operation, and would not be expected to be major.	No transportation impacts would occur because all spent fuel elements have been removed.

Table S.8-1. Comparison of Alternatives — Continued.

Resource	Alternative:				
	No Action	30 MW	60 MW	Enhanced	Shutdown
Public and Occupational Health and Safety — Radiological	<i>Impacts to Public^a</i> Airborne releases would be approximately 27 Ci H ³ annually. All other radionuclides would have releases of <1 mCi. The total population dose from HFBR air emissions would be 0.0098 person-rem/yr, which represents a potential latent cancer fatality (LCF) of 4.9×10^{-6} .	<i>Impacts to Public^b</i> Airborne releases would be approximately 98 Ci H ³ and 2 mCi of Br ⁸² annually. All other radionuclides would have releases of <1 mCi. The total population dose from HFBR air emissions would be 0.035 person-rem/yr, which represents a potential LCF of 1.7×10^{-5} .	<i>Impacts to Public^c</i> Airborne releases would be approximately 190 Ci H ³ and 3 mCi of Br ⁸² annually. All other radionuclides would have releases of <1 mCi. The population dose from HFBR air emissions would be 0.069 person-rem/yr, which represents a potential LCF of 3.4×10^{-5} .	<i>Impacts to Public</i> A prerequisite to HFBR reactor vessel replacement would be the removal of the existing vessel and internal components. Component segmentation depends on component activation. Components requiring segmentation, transportation, and shielding (approximately 23,000 kg) would involve approximately 800,000 Ci of total activity. Doses associated with handling this material would be determined by the method of segmentation, transportation, and shielding selected.	<i>Impacts to Public</i> During long-term surveillance and maintenance (S&M), doses would decrease slightly over time. Activities for S&M are similar to defueled reactor maintenance, and would be the same as the No Action Alternative.
	Total dose to the maximally exposed individual (MEI) would be 8×10^{-5} mrem/yr, which represents a potential LCF of 4.0×10^{-11} .	The total dose to the MEI would be 3.0×10^{-4} mrem/yr, which represents a potential LCF of 1.5×10^{-10} .	The total dose to the MEI would be 5.6×10^{-4} mrem/yr, which represents a potential LCF of 2.8×10^{-10} .	Operation of the reactor following enhancement would result in the same impacts as presented for 60 MW operation.	

Table S.8-1. Comparison of Alternatives — Continued.

Resource	Alternative:				
	No Action	30 MW	60 MW	Enhanced	Shutdown
Public and Occupational Health and Safety — Radiological, Continued	<u>Impacts to Workers</u> The average dose to workers would be 98 mrem/yr. The maximally exposed worker would receive approximately 520 mrem/yr, which represents a potential LCF of 1.9×10^{-3} .	<u>Impacts to Workers</u> The average dose to workers would be approximately 135 mrem/yr. The maximally exposed worker would receive approximately 635 mrem/yr, which represents a potential LCF of 5.5×10^{-3} .	<u>Impacts to Workers</u> The average dose to workers would be approximately 205 mrem/yr. The maximally exposed worker would receive approximately 870 mrem/yr, which represents a potential LCF of 8.4×10^{-3} .	<u>Impacts to Workers</u> Enhancement activities would cause worker doses for this Alternative to increase in comparison to other Alternatives. Operation of the reactor following enhancement would result in the same impacts as presented for 60 MW operation.	<u>Impacts to Workers</u> Placement of the reactor in an industrially and radiologically safe condition would involve some worker dose from removal of radioactive systems and subsystems, equipment, and structures associated with the reactor. The doses would be expected to be similar to defueling activities. Impacts from S&M activities would be the same as for the No Action Alternative.
	All radiological doses to the public and workers related to air emissions and water discharges would be below levels established to protect human health.				
Public and Occupational Health and Safety — Chemical	No actions at the HFBR would be expected to introduce large quantities of chemicals.	Chemicals required for reactor operation (e.g., sulfuric acid for cooling water system conditioning, lithium chromate for corrosion inhibitor, and cadmium nitrate for poison water system) would remain. Hazards associated with these chemicals would have minor impacts.		No large quantity of chemicals would be expected to be introduced to the HFBR for enhancement purposes.	Large quantities of chemicals are typically not introduced during deactivation activities. Chemicals not associated with deactivation would be reduced because they would no longer be needed. Chemicals such as sulfuric acid, cadmium nitrate and others would be removed. Impacts from the reduced chemical inventory would be small.
		The amounts of chemicals stored at the HFBR would be independent of the level of reactor power.			

Table S.8-1. Comparison of Alternatives — Continued.

Resource	Alternative:				
	No Action	30 MW	60 MW	Enhanced	Shutdown
Public and Occupational Health and Safety ----- Accidents ^d	No accidents involving nuclear fuel could occur in the defueled condition. Accidents involving D ₂ O coolant, experimental quantities of radionuclides, and contaminated portions of the facility would not be expected to result in significant airborne releases.	<p>The severe wind/tornado is the scenario with the highest consequences^c. The frequency of this event is 7.9×10^{-7}/yr.</p> <p>The potential LCF to the MEI would be 6×10^{-2} per accident occurrence.</p> <p>The potential LCF to the onsite noninvolved worker population would be 1.1 per accident occurrence.</p> <p>The potential LCF to the offsite population would be 81 per accident occurrence.</p>	<p>The severe wind/tornado is the scenario with the highest consequences. The frequency of this event is 8.7×10^{-7}/yr.</p> <p>The potential LCF to the MEI would be 0.11 per accident occurrence.</p> <p>The potential LCF to the onsite noninvolved worker population would be 1.3 per accident occurrence.</p> <p>The potential LCF to the offsite population would be 115 per accident occurrence.</p>	<p>Enhanced</p>	<p>Shutdown</p> <p>Core damage accidents could not occur because there would be no fuel in the HFBR.</p> <p>A D₂O release could occur during a transition to a permanent shutdown state, but could not occur once the transition has been made.</p> <p>Accidents involving the release of D₂O or contaminated portions of the facility would not be expected to result in significant airborne releases.</p>

Table S.8-1. Comparison of Alternatives — Continued

Resource	Alternative:				
	No Action	30 MW	60 MW	Enhanced	Shutdown
Waste Management — Spent Nuclear Fuel	In the current defueled condition, the HFBR would generate 0 kg/year. There would be no impact associated with disposal of SNF.	Up to 77 HEU fuel elements would be consumed annually. This amount of SNF would equal approximately 8% of BNL's storage capacity (1,000 elements). This would not have a significant impact on BNL's waste management operations.	Up to 158 HEU fuel elements would be consumed annually. This amount of SNF would equal approximately 16% of BNL's storage capacity (1,000 elements). This would not have a significant impact on BNL's waste management operations.		No nuclear fuel would be delivered to or used in the HFBR
Waste Management — Liquid LLW	Sampling and maintenance operations would generate 80 m ³ /year. BNL storage capacity is 265 m ³ /yr. This generation rate is approximately 30% of BNL storage capacity, and would not have a significant impact on BNL's waste management operations.				Maintenance would result in 38 m ³ /yr. Draining primary and support systems would result in a one-time generation of 80 m ³ which would likely be recycled for other research applications. The annual generation rates would be less than 15% of BNL's storage capacity, and would not be a significant impact on BNL waste management operations.

Table S.8-1. Comparison of Alternatives — Continued

Resource	Alternative:				
	No Action	30 MW	60 MW	Enhanced	Shutdown
Waste Management — Solid LLW	Maintenance, surveillance, and monitoring operations would generate 23 m ³ /year. This rate is approximately 4.3% of BNL's storage capacity (540 m ³ /yr), and would not have a significant impact on BNL's waste management operations.	Research, monitoring, surveillance, and maintenance operations would generate 37 m ³ /year. This rate is approximately 6.9% of BNL's storage capacity (540 m ³ /yr), and would not have a significant impact on BNL's waste management operations.	More frequent fuel handling and numbers of fuel element cut ends would result in an increased generation rate over 30 MW operations. 42 m ³ /year would be generated, which is approximately 7.8% of BNL's storage capacity (540 m ³ /yr), and would not have a significant impact on BNL's waste management operations.	Replacement of the reactor vessel, experimental beam tubes, upper thermal shield, and reactor internals would result in a one-time generation of 30 m ³ . After which, generation rates would be the same as 60 MW operation (42 m ³ /year). This rate would be approximately 7.8% of BNL's storage capacity (540 m ³ /yr), and would not have a significant impact on BNL's waste management operations.	Reduced maintenance, surveillance, and monitoring would generate 11 m ³ /year, which is approximately 2.0% of BNL's storage capacity. A one-time operation to remove non-reactor components in preparation for D&D would generate 60 m ³ . This rate would not have a significant impact on BNL's waste management operations.
Waste Management — Mixed Waste	Routine maintenance would generate 1.3 m ³ /year. This rate is approximately 6.8% of BNL's storage capacity (19 m ³ /yr), and would not have a significant impact on BNL's waste management operations.	HFBR operations would generate 1.7 m ³ /year. This rate is approximately 8.9% of BNL's storage capacity (19 m ³ /yr), and would not have a significant impact on BNL's waste management operations.			Removal of contaminated lead and beam plugs would generate 15 m ³ the first two years. 1.0 m ³ /year would be generated thereafter from monitoring and surveillance activities. This generation rate is approximately 5.2% of BNL's storage capacity (19 m ³ /yr), and would not have a significant impact on BNL's waste management operations.

Table S.8-1. Comparison of Alternatives — Continued

Resource	Alternative:				
	No Action	30 MW	60 MW	Enhanced	Shutdown
Waste Management —— Hazardous Waste	Routine maintenance would generate 1.8 m ³ /year. Hazardous waste is disposed of by a vendor on an as needed basis. This generation rate is approximately 1.5% of BNL's storage capacity (117 m ³ /yr), and would not have a significant impact on BNL's waste management operations.	Routine maintenance would generate 2.4 m ³ /year. Hazardous waste is disposed of by a vendor on an as needed basis. This generation rate is approximately 2.1% of BNL's storage capacity (117 m ³), and would not have a significant impact on BNL's waste management operations.			Removal of lead and other heavy metals during the first two years would generate 5 m ³ . After that time, 1.0 m ³ /year would be generated from monitoring and surveillance activities. Hazardous waste is disposed of by a vendor on an as needed basis. This generation rate is approximately 0.9% of BNL's storage capacity (117 m ³), and would not have a significant impact on BNL's waste management operations.
Waste Management —— Industrial Waste	Routine maintenance would generate less than 1% of BNL's total. Industrial waste is disposed of by a vendor on an as needed basis. This generation rate would not have a significant impact on BNL's waste management operations.				

Table S.8-1. Comparison of Alternatives — Continued

Resource	Alternative:				
	No Action	30 MW	60 MW	Enhanced	Shutdown
Environmental Justice	Because there would be no significant adverse socioeconomic or health impact on any offsite population, there would be no disproportionate adverse impacts to either low-income or minority populations.				
Cumulative Impacts	Ongoing repair and maintenance actions at HFBR facilities that are unrelated to proposed alternatives will likely reduce the potential for future adverse impacts to groundwater. Under continued shut down status, HFBR incremental contribution to effects on radiological air quality, groundwater, human health, or radiological waste management capabilities would not result in significant cumulative impacts.	HFBR incremental contribution to impacts on radiological air quality, groundwater, human health, and radiological waste management capabilities would not result in significant adverse incremental or cumulative impacts. However, if the Spallation Neutron Source had been sited at BNL, there may have been a significant cumulative impact on BNL waste management operations.	HFBR operation at 60 MW would include an incremental contribution to cumulative air quality impacts and subsequent impacts to Human Health. These impacts would not be significant incrementally or cumulatively. No incremental contribution to groundwater impacts would be expected. HFBR incremental contribution to radiological waste management impacts would not be significant. However, if the Spallation Neutron Source had been sited at BNL, there may have been a significant cumulative impact on BNL waste management operations.	Enhanced operation impacts would be expected to be the same as 60 MW operations. However, if the Spallation Neutron Source had been sited at BNL, there may have been a significant cumulative impact on BNL waste management operations.	Shutdown impacts would be similar to No Action. However, if the Spallation Neutron Source had been sited at BNL, there may have been a significant cumulative impact on BNL waste management operations.

^a Based on data in 1990 BNL *Site Environmental Report* when HFBR was operating at 0 MW.

^b Based on data in 1995 BNL *Site Environmental Report* when HFBR was operating at 30 MW.

^c Based on data in 1988 BNL *Site Environmental Report* when HFBR was operating at 60 MW.

^d The four potential accident scenarios presented in detail in Chapter 4 of the DEIS include: 1) loss of offsite power (LOOP); 2) large loss of coolant accident (LOCA); 3) severe wind/tornado; and 4) fuel handling accident. For comparison, only the severe wind/tornado accident is presented because it depicts the highest consequences.

^e Potential severe wind/tornado causes loss of offsite power, breaches confinement with a projectile and also eliminates then-existing coolant makeup. The release is not filtered because confinement is breached.

S.9 REFERENCES

- ADL 1984 Arthur D. Little, Inc., *Irradiated Fuel Shipping Alternatives Through Or Around New York City*. Prepared for the Law Department, City of New York, Document No. 52724. December 18, 1984.
- BNL 1997 Chang, L.Y., and P.R. Tichler, *High Flux Beam Reactor (HFBR) Flow Reversal Power Limit Analysis*, Reactor Division, BNL-52497-97/01-REV, Brookhaven National Laboratory, Upton NY, January 1997.
- DOE 1997 DOE *High Flux Beam Reactor (HFBR) Spent Fuel Transportation Plan (Revision 7)*, April 1997.
- DOE 1998 DOE *Approval of the High Flux Beam Reactor (HFBR) Flow Reversal Power Limit Analysis*, memorandum from Robert G. Lange, Office of Nuclear Energy, Science and Technology, May 19, 1998.
- NRC 1999 NRC, *U.S. Nuclear Regulatory Commission Safety Assessment of the High Flux Beam Reactor at the Brookhaven National Laboratory*, February 23, 1999. At URL <http://www.nrc.gov/OPA/reports/nrc.html>.